

Artificial Intelligence and Inventive Step:
A European Patent Law Perspective

DISSERTATION
at the Faculty of Law
of the Ludwig Maximilian University Munich

submitted by
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2025

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Munich/München, _____

ABSTRACT

Artificial Intelligence (AI) is empowering advancements and innovations that would otherwise be unimaginable through human creative and inventive ability alone. It is arguably transforming the way inventions are made, calling into question the core principles of patent law. This work focuses on the possibility of patenting inventions aided or generated by AI, with a particular focus on examining the rationale and mechanisms of the inventive step requirement under the European Patent Convention (EPC) and in the practice of the European Patent Office (EPO).

The inventive output of AI systems can be classified into various categories, with two primary ones: in the first, both a human and an AI are part of the inventive process (“AI-assisted inventions”), whilst in the second, more hypothetical scenario, AI operates independently to create inventions (“AI-generated inventions”). As technological advancements make it increasingly difficult to distinguish and determine the origin of the inventive input, both will be collectively referred to as “AI-related inventions” in this work.

With the increasing use of AI in the inventive process, questions arise as to how the current standards for assessing the inventive step are affected by the presence of AI in the inventive process, whether they remain appropriate, and if specific provisions for AI-related inventions should be introduced, including updates to the current inventive step requirement. In general, the inventive step is assessed by asking whether the claimed invention would be obvious to a person skilled in the art, given the known prior art (Article 56 EPC). This research focuses on the possible particularities when assessing the inventive step in AI-related inventions. This includes the definition, skills and knowledge of the person skilled in the art and leads to the question of whether the description of the skilled person should be adapted to include AI as a research tool once the average person in the field (or fields) to which the invention relates would have been expected to use it, at the relevant date. The determination if AI is a commonly used tool would happen through rules for determining the “common general knowledge” of the skilled person and be assessed on a case-by-case basis. Moreover, AI’s ability to rapidly generate and analyse vast amounts of information poses challenges for patent examination, particularly in assessing the state of the art and prior art for AI-related inventions. This capability raises questions about how to adapt existing patent standards, including the inventive step requirement, and how to effectively incorporate AI into the patent examination process while maintaining the integrity and fairness of the system. Furthermore, this work focuses on examining the current standards of sufficiency of disclosure concerning AI-related inventions. The standards of sufficiency of disclosure are set to ensure that the person skilled in the art can carry out the claimed invention based on the patent specification. Different theories have been elaborated regarding the necessity of adjusting the current laws and guidelines, which will be debated.

Against this background, this research contributes to the ongoing debate on the patentability of AI-related inventions. The study highlights the need for adjustments to the current inventive step requirement and the possibility of introducing new provisions to the patent system to address the unique characteristics of AI-related inventions. The findings of this research are

expected to be of interest to scholars and practitioners in the field of intellectual property law and AI, as well as policymakers involved in shaping the future of patent law.

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ACRONYMS AND ABBREVIATIONS

AAAI	Association for the Advancement of Artificial Intelligence
ACM	Association for Computing Machinery
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AIAA	American Institute of Aeronautics and Astronautics
AIPPI	<i>Association Internationale pour la Protection de la Propriété Intellectuelle</i> (International Association for the Protection of Intellectual Property)
BBC	British Broadcasting Corporation
BGH	<i>Bundesgerichtshof</i> (Germany's Federal Court of Justice)
BoA	Boards of Appeal of the European Patent Office
CCR2	C-C Chemokine Receptor Type 2
CEO	Chief Executive Officer
CERN	<i>Conseil Européen pour la Recherche Nucléaire</i> (European Organization for Nuclear Research)
CIPA	Chartered Institute of Patent Attorneys (UK)
CNN	Convolutional Neural Network; Cable News Network
COM	Commission Document
COVID	CoronaVirus Disease
CPI	<i>Codice della Proprietà Industriale</i> (Italian Industrial Property Code)
DABUS	Device for the Autonomous Bootstrapping of Unified Sentience
DMA	Digital Markets Act
DNA	Deoxyribonucleic Acid
DOC	Document
Dr.	Doctor
DSM	Digital Single Market
EBA	Enlarged Board of Appeal of the EPO

EC	European Commission
ed(s)	Editor(s)
EFPIA	European Federation of Pharmaceutical Industries and Associations
EIPR	European Intellectual Property Review
EMA	European Medicines Agency
ENIAC	Electronic Numerical Integrator and Computer
EP	European Patent
EPA	<i>Europäisches Patentamt</i> (European Patent Office)
EPC	European Patent Convention
EPLR	European Pharmaceutical Law Review
EPO	European Patent Office
EPÜ	<i>Europäisches Patentübereinkommen</i> (European Patent Convention)
et al.	<i>et alii</i> (and others)
et seq.	<i>et sequentia</i> (and the following)
EU	European Union
EUR	Euro
EWCA	England and Wales Court of Appeal
EWHC	England and Wales High Court
FDA	Food and Drug Administration
FSR	Fleet Street Reports
GAFAM	Google, Apple, Facebook, Amazon e Microsoft
GDPR	General Data Protection Regulation
GebrMG	<i>Gebrauchsmuster</i> (German utility model)
GPT	Generative Pre-trained Transformer
GRUR	<i>Gewerblicher Rechtsschutz und Urheberrecht</i> (Association for Intellectual Property Law)
HSU	Helmut Schmidt University (Hamburg)
ibid.	<i>ibidem</i> (in the same place)

IHRIM	International Association of Information Resources Management
IP	Intellectual Property
IPR	Intellectual Property Rights
IPWatchDog	Intellectual Property Watch Dog
IQ	Intelligence Quotient
IT	Information Technology
JIPITEC	Journal of Intellectual Property, Information Technology and E-Commerce Law
JIPLP	Journal of Intellectual Property Law & Practice
JNK	c-Jun N-terminal Kinase
KI	<i>Künstliche Intelligenz</i> (Artificial Intelligence)
KRAS	Kirsten Rat Sarcoma
LL.M.	<i>Legum Magister</i> (Master of Laws)
LLM(s)	Large Language Model(s)
LMU	Ludwig Maximilian University (Munich)
MIPLC	Munich Intellectual Property Law Center
MIT	Massachusetts Institute of Technology
MOSITA	Machine Having Ordinary Skills in the Art
MPEP	Manual of Patent Examining Procedure
MPI	Max Planck Institute for Innovation and Competition
NASA	National Aeronautics and Space Administration
NBER	National Bureau of Economic Research
OECD	Organisation for Economic Cooperation and Development
OUP	Oxford University Press
OJ	Official Journal
PatG	<i>Patentgesetz</i> (Patent Law)
PCT	Patent Cooperation Treaty
PhD	<i>Philosophiae Doctor</i> (Doctor of Philosophy)

PHOSITA	Person Having Ordinary Skill in the Art
PID	Proportional-Integral-Derivative
PNRR	<i>Piano Nazionale di Ripresa e Resilienza</i> (National Recovery and Resilience Plan)
Prof.	Professor
PSITA	Person Skilled in the Art; also referred to as “Skilled Person”
R&D	Research and Development
RNN	Recurrent Neural Network
SARS-CoV-2	Severe Acute Respiratory Syndrome CoronaVirus 2
SCP	Standing Committee on the Law of Patents (WIPO)
SCRIPT	School of Computing, Robotics and Engineering Innovation Programme for Teaching (University of Edinburgh)
SDG	Sustainable Development Goal
SSRN	Social Science Research Network
TEU	Treaty on European Union
TRIPs	Agreement on Trade Related Aspects of Intellectual Property Rights
UCLA	University of California Los Angeles
UK	United Kingdom
UKSC	Supreme Court of the United Kingdom
UNTS	United Nations Treaty Series
UPC	Unified Patent Court
UPCA	Unified Patent Court Agreement
US	United States
USC	United States Code
USCA	United States Code Annotated
USD	United States Dollar
USPTO	United States Patent and Trademark Office
vs./v	<i>versus</i> (against)

WIPO	World Intellectual Property Organization
WTO	World Trade Organization

A. INTRODUCTION AND COURSE OF EXAMINATION

I. Background and Purpose

Recent advances in AI have been remarkable and are expected to significantly impact numerous domains over the coming decades, including the patent system. If AI is conceptualised along a spectrum, at one end, a computer functions merely as a tool assisting a human inventor without contributing to the inventive process, for instance, through spell-checking or performing basic calculations. Progressing along the spectrum, AI may be employed to fill gaps in patent records, assist in the evaluation of patent applications, and potentially support the identification of patent infringements. Furthermore, it may serve as a component within inventions that themselves may be eligible for patent protection. At the far end of the spectrum, AI could autonomously generate inventive outputs and be regarded as an (or the sole) “inventor” of subject matter that, if created by a human, would qualify as a patentable invention under the current legal framework.

As AI capabilities advance in data processing, machine learning algorithms, and computational power, these “inventive machines” are becoming increasingly sophisticated tools for augmenting innovation processes. They are poised to significantly alter the innovation process, making it faster and more effective in certain technological domains or for specific types of inventions.¹

Currently, there are unsolved issues surrounding AI-related inventions. Advancements in technology have pushed the patent system to confront a new reality where AI may increasingly replace human intelligence in inventive processes. This shift is changing the balance between human and machine contributions in innovation, with AI playing an increasingly significant role. The matter has gained particular momentum with the DABUS patent applications, where Professor Ryan Abbott’s team filed patent applications designating an AI system as the inventor in various patent offices worldwide, as part of the Artificial Inventor Project, questioning whether an AI system can be named as an inventor in a patent application.² DABUS, an AI

¹ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1455 https://southerncalifornialawreview.com/wp-content/uploads/2024/04/Wasserman_Final.pdf.

² For a general discussion see: Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 1 et seq.; see also: Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1079 <https://ssrn.com/abstract=2727884>; Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 489; Shlomit Yansky-Ravid and Ziaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: An Alternative Model for Patent Law at the 3A Era’ (2018) 39 *Cardozo Law Review* 2217; Kemal Bengi and Christopher Heath, ‘Patents and Artificial Intelligence Inventions’ in Christopher Heath, Anselm Kamperman Sanders, and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 144-145; Angela Chen, ‘Can an AI Be an Inventor? Not Yet.’ (MIT Technology Review, 8 January 2020) <https://www.technologyreview.com/2020/01/08/102298/ai-inventor-patent-dabus-intellectual-property-uk-european-patent-office-law/>; A J Willingham, ‘Artificial Intelligence Can’t Technically Invent Things, Says Patent Office’ (CNN, 30 April 2020) <https://edition.cnn.com/2020/04/30/us/artificial-intelligence-inventing-patent->

system developed by Stephen Thaler, claims to have conceived inventions beyond the purview of human imagination.³ Unfortunately, the decisions on DABUS focus on the question of human/AI-inventorship without evaluating the actual autonomy of the AI system. The decisions miss to follow up the question on whether the limitation of the inventor concept to a natural person *should* be reconsidered due to the technological developments in the field of AI. Solely the United States decision clarified that *Thaler's* claims regarding the “autonomous” generation of inventions do not hold against the technological state of the art.⁴ Still, the court missed an opportunity to reflect on considerations *de lege ferenda* which could potentially be useful for the future. Nevertheless, DABUS represents just one facet of the broader landscape, where various AI systems semi-or autonomously generate inventions that seem to meet the criteria for patent protection within the existing patent frameworks.⁵

While the question of AI inventorship has received considerable scholarly attention in recent years, this work focuses instead on the inventive step requirement, a central criterion of patentability that remains comparatively under-researched in the context of AI. Existing literature on AI and patent law has primarily focused on issues of inventorship (see, for example, Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021); Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023); Oskar Paulini, *Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz* (Munich 2023); Josef Drexl et al., ‘Artificial Intelligence Systems as Inventors? A Position Statement of 7 September 2021 in view of the evolving case-law worldwide’ (Max Planck Institute for Innovation and Competition Research Paper No. 21-20, 2021); Martin Stierle, ‘Artificial Intelligence Designated as Inventor - An Analysis of the Recent EPO Case Law’ (2020) *GRUR International* 918), while more detailed engagement with the assessment of the inventive step in European Patent Law is limited (see, for example, Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024). Some contributions, in particular from *Abbott*, *Stierle*, *Dornis* and *Drexl* have addressed the broader implications of AI for innovation policy, but do not sufficiently examine the legal reasoning applied by the EPO when evaluating inventive step in AI-related patent applications. This indicates a significant research gap.

The relevance of this topic lies in the growing use of AI in inventiveness, which challenges existing legal frameworks, particularly regarding how the inventive step is assessed under the EPC. Addressing this question is crucial for ensuring legal certainty in the evolving technological landscape. While AI seems to be improving exponentially, human researchers are not at the same level and speed. Even in the short-to-medium term, this means that inventive

officetrnd/index.html; Leo Kelion, ‘AI System “Should Be Recognized as Inventor”’ (BBC, 1 August 2019) <https://www.bbc.com/news/technology-49191645>.

³ Jared Council, ‘Can an AI System Be Given a Patent?’ (Wall Street Journal, 11 October 2019) <https://www.wsj.com/articles/can-an-ai-system-be-given-a-patent-11570801500>.

⁴ United States Court of Appeals for the Federal Circuit - *Thaler v Vidal*, 43 F.4th 1207 (Fed. Cir. 2022).

⁵ Michael McLaughlin, ‘Computer-Generated Inventions’ (2019) 101 *Journal of Patent & Trademark Office Society* 238-239. For other examples see Ben Hattenbach and Joshua Glucoft, ‘Patents in an Era of Infinite Monkeys and Artificial Intelligence’ (2015) 19 *Stanford Technology Law Review* 44.

AI may become a significant part of research and development. When it does, it will be seriously problematic if the patent system lacks clear rules on whether and how AI-related inventions can be protected.

II. Terminology and Disambiguation on “AI-Inventions”

AI poses a challenge in its definition due to its multifaceted nature, primarily associated with computers’ capacity to acquire knowledge. For the purposes of this work, the term AI refers to machine-based systems capable of performing tasks traditionally reliant on human cognitive abilities, while operating with varying levels of autonomy and adaptiveness to generate outputs such as predictions, recommendations, or decisions.⁶

In this context, the collocation “AI-related inventions” refers to inventions that are enhanced or enabled using AI algorithms, machine learning models, evolutionary algorithms and other techniques that fall under the AI spectrum in phases of the inventive process. These inventions involve the integration of AI algorithms, models, or systems to enhance various aspects of the invention process, optimizing performance, increasing efficiency, enabling new functionalities, improving decision-making processes, or enhancing the overall quality of the invention.⁷ AI can assist inventors in generating more accurate simulations, conducting advanced data analysis, automating repetitive tasks, identifying patterns or trends, or even suggesting new ideas based on large datasets. The term underlines the collaborative nature of the invention process, where AI provides valuable insights, by both augmenting the capabilities of human inventors and, to some degree of autonomy, contributing to the overall inventive output, leading to a future where AI may be able to invent completely autonomously.

While patenting AI-assisted inventions appears feasible under current patent laws with minor adjustments to EPO Guidelines, more substantial changes will be necessary to one day accommodate fully autonomously AI-generated inventions (see Section B.III.2.b)cc). As the distinction between these two categories becomes increasingly blurred, it is crucial to develop a comprehensive response addressing all AI-related inventions. The discussion, therefore, focuses on AI both as a tool in the invention process and as an inventor of fully autonomous inventions. Despite the clear differences between these domains, several key arguments remain applicable across both.

For the purposes of this dissertation, the terms “machine”, “computer”, “AI(-system)”, and “software” are employed with context-specific meanings. “Machine” refers to the physical hardware apparatus, “computer” represents a programmable electronic device capable of executing instructions, “AI” designates computational models and methods designed to perform tasks typically requiring human cognition, and “software” refers to the coded instructions and

⁶ This approach follows the definition in the EU AI Act, later discussed in Section B.I.3; see also: ‘Article 3: Definitions’, Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) [2024] OJ L2024/1689.

⁷ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1456.

programs implementing functionalities on a machine or computer. In instances where the precise distinction between these terms does not materially affect the analysis, they may be used interchangeably for the sake of readability.

III. Research Questions

The central research question of this work is how the increasing use of AI in the inventive process affects the assessment of the inventive step under the EPC. In addressing this, this work will also examine how EPO Guidelines can be adapted to AI-related inventions for a *de lege lata* approach and whether *de lege ferenda* provisions are necessary to the EPC.

This work fills a gap in the existing literature by focusing on AI's impact on the inventive step, which has been under-explored, especially in the context of the EPC and EPO Guidelines, compared to questions surrounding computer-implemented inventions and AI inventorship. This thesis is therefore explicitly not an answer to the question of whether AI itself or the underlying algorithm or software can be protected by patent law. The question of whether AI can be named as an inventor is also not the topic of this research. These two issues are legally unrelated, as they are based on different and non-overlapping factual circumstances. Due to the extensive coverage in numerous international publications in recent years (and ongoing discussions), these questions will be excluded from the examination.

While naming AI as an inventor is one of the many questions that patent law currently faces, even before considering that, there is a need to clarify if inventions generated with the help or autonomously by AI meet all the necessary patent requirements. Patent offices, including the EPO, assess patentability first by determining whether a claimed subject-matter has technical character (thus, is an “invention” under Article 52(1) EPC), and then evaluate whether it meets the three substantive requirements of novelty, inventive step, and industrial applicability. Importantly, inventive step is the cornerstone of the patentability test.

In light of these considerations, this research examines the impact of the increasing use of AI in the invention process on the assessment of the inventive step under the EPC and in the practice of the EPO. Under Article 56 EPC, an invention involves an inventive step if, for a person skilled in the art, it is not obvious in light of the state of the art. The requirement of the inventive step aims to ensure that patents are awarded only for outcomes stemming from an inventive or creative effort, rather than for processes that a person skilled in the relevant technical field could easily derive from existing knowledge. Thus, this work examines potential unique aspects in evaluating the inventive step for AI-related inventions. It investigates how this concept is altered by contemporary advancements in AI and whether the threshold for inventiveness may shift in response to AI's growing capabilities.

Additionally, it explores how AI's involvement in the invention process influences the assessment of inventive step, the suitability of the “person skilled in the art” construct in an AI-driven innovation landscape and the comparison of criteria applied to AI-related inventions versus human-generated inventions. The emergence of inventive AI causes numerous implications for the person skilled in the art, beginning with the definition that would need to

reflect the changing technological landscape and ensure that the patent system can effectively evaluate inventions made by AI. It moreover explores the skills and knowledge of the person skilled in the art, questioning whether this concept should be updated to incorporate AI as a research tool once it becomes expected in the relevant field(s) at the pertinent date. Although AI is often viewed as a mere tool, its impact on the level of inventiveness is significant, particularly in enhancing the capabilities of human inventors in achieving more complex results. The routine application of AI in the development of inventions could, however, challenge the assessment of inventive step.⁸ The determination of AI as a common tool would be based on established rules for assessing the “common general knowledge” of the skilled person, evaluated case-by-case.

The research also considers the impact of a changing prior art landscape on inventive step assessment for AI-related inventions. Advanced AI systems’ capacity to rapidly process vast amounts of prior art challenges traditional patent both in the notion of what can be considered the relevant prior art and the examination methods, prompting discussions on how to refine existing standards and effectively incorporate AI tools.

Another critical aspect that is explored, is the evaluation of whether current standards of sufficiency of disclosure are adequate for AI-related inventions, ensuring that a person skilled in the art can implement the claimed invention based on the patent specification. This includes addressing challenges related to the disclosure of AI algorithms and datasets, as well as issues of reproducibility and transparency.

Additionally, the research examines broader implications of the influence of AI advancements on patent law, including the justification for patent protection for AI-related inventions, and alternative mechanisms for protecting AI-related inventions.

IV. Structure and Course of Examination

This work adopts a normative approach to address how the patent system should adapt to AI-related inventions and explores the implications of inventive machines. The structure of this thesis is designed to systematically explore the intersection between AI and patent law, particularly focusing on the challenges and implications of AI-related inventions within the framework of the EPC.

After a brief outline of the main topics, research questions, and methodological approach in Part A (Introduction and Course of Examination), the dissertation proceeds to its conceptual and doctrinal analysis.

Part B (Conceptual Foundations of AI) provides the necessary technological and definitional background. It begins with an overview of the historical milestones in the development of AI and the evolving attempts to define it (B.I), with particular attention to the lack of a unitary

⁸ Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 5 https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/MPI_PositionPaper__SSRN_21-10.pdf.

legal definition and its implications for regulatory harmonisation (B.I.3). This is followed by a technological overview of AI systems and their subtypes (B.II.1), including machine learning (B.II.1.a), artificial neural networks (B.II.1.b), evolutionary algorithms (B.II.1.c), generative AI (B.II.1.d), and inventive AI (B.II.1.e), culminating in a discussion of their different operational levels (B.II.2) and the implications for innovation. Next, Section B.III classifies AI-related outputs, distinguishing between AI-assisted (B.III.2.a) and AI-generated inventions (B.III.2.b), the latter being further subdivided in semi-, highly-, and fully-autonomous generation modes (B.III.2.b.aa-cc). Finally, Section B.IV examines key industrial sectors-particularly pharmaceuticals and medical technologies, where AI applications are currently most promising and where AI-generated inventions are increasingly relevant.

Part C (The Interconnection between AI and Patent Law) provides the normative and legal backdrop by analysing the rationale for patent protection (C.I), including the reward-by-monopoly theory (C.I.2.a), the natural rights theory (C.I.2.b), the disclosure theory (C.I.2.c), and the incentive theory (C.I.2.d), each critically applied to AI-related inventions. This is followed by an overview of the current patent frameworks in the international, US, and European contexts, including the EPC and the Unitary Patent Package (C.II). Section C.III explores the patentability criteria under the EPC, particularly inventive step, and the EPO's problem-and-solution approach (C.IV.3), setting the stage for identifying the legal tensions that AI introduces into patent assessment.

Part D (AI and the Person Skilled in the Art) shifts the focus to the evolving identity and evaluative function of the person skilled in the art, a cornerstone of the inventive step analysis under Article 56 EPC. It begins with a doctrinal analysis of the person skilled in the art's role in patent law (D.I) and proceeds to consider how AI tools may form part of the person skilled in the art's toolkit (D.II), including whether such tools (or the use thereof) can constitute part of the common general knowledge (D.III.2) and how the inclusion of AI affects assessments of obviousness (D.IV). This part ends in a proposal for a hybrid concept of the skilled person, the "Skilled Person 2.0", that accommodates both human expertise and AI capabilities (D.V.3).

Part E (Redefining the State of the Art and Relevant Prior Art for AI) addresses how AI affects the determination and accessibility of prior art. It assesses the implications of AI-related outputs for the concept of the state of the art (E.I.2) and examines the use of AI tools in prior art searches by patent offices (E.II.1).

Part F (Sufficiency of Disclosure in the Light of AI) investigates the challenges that AI poses to Article 83 EPC, including the so-called "black box" problem and the difficulties in disclosing datasets and training processes (F.I.2). It evaluates whether additional disclosure obligations should be imposed and how EPO Guidelines could evolve to better reflect the nature of AI-related inventions (F.II.2-3).

Part G (Proposals for a Revised Patent Framework) offers a forward-looking perspective, evaluating several reform models for the adaptation of the patent system to the realities of AI innovation. This includes proposals for expedited examination procedures, two-track systems, and harmonised depository requirements (G.I.2). It also reflects on institutional challenges and

recommends updates to the EPO Guidelines to ensure procedural robustness and policy coherence (G.I.4).

Finally, Part H (Conclusion) synthesises the findings of each part and advocates for targeted updates to the legal and procedural framework, especially within the EPO Guidelines, to ensure the EPC remains effective and equitable in accommodating AI-driven innovation.

This structure provides a thorough examination of both the technological foundations of AI and its legal implications, ultimately aiming to contribute to the ongoing discourse on how patent law and in particular the inventive step should evolve in response to the challenges posed by AI. To address the research questions raised in this thesis, this approach involves examining relevant legal provisions, in particular the EPC, the practice of the EPO and its Guidelines, case law and academic literature to identify and interpret legal rules, principles, and concepts. At times, a comparative analysis of how different national and regional patent offices and courts handle the matter is conducted to gain insight into potential solutions or best practices. The research is also based on conversation with patent examiners, attorneys, and AI experts to gain practical understanding of the current patent system and how it could be improved. Throughout this work both *de lege lata* and *de lege ferenda* approaches are debated. Proposals are made for amendments or additions to the EPC and suggestions for EPO Guidelines to ensure legal certainty.

V. Motivation and Contribution to the Legal Debate

The motivation for this research arises from the recognition of AI's profound impact, unlike any other technological advancement before it, on the inventive process and the pressing need to reassess how existing legal frameworks address these changes. There are countless examples of how in the past, law has reacted slowly to technological change. As far as the state of technology is concerned, it is difficult to predict the future. Innovative technologies often bring about significant challenges, and AI inventions are certainly no exception. The proliferation of AI-driven inventions and the safeguarding of intellectual property present new complexities within the patent framework.

This research is motivated by the need to bridge this gap by critically examining how inventive step requirement under the EPC and the practices of the EPO can be adapted to accommodate AI-related inventions. The integration of AI into the invention process introduces unprecedented challenges that have not yet been fully explored. The conventional approaches to assessing inventiveness, such as the “person skilled in the art” standard, may no longer be fully adequate in a scenario where AI is capable of processing vast amounts of prior art and contributing to, or even independently generating, new inventions.

Given the significant role of AI in modern innovation, the patent system needs to evolve to effectively balance the protection of AI-related inventions with the promotion of further technological advancement. The principles that guide patent law need to be, if not rethought, at least retooled in respect of AI inventiveness. The surge in patent applications has led to an increase in patents of varying quality, the emergence of patent trolls, and a flood of patent

filings. These outcomes reflect the efficiency enhancements introduced by AI in innovation. If AI can generate inventive ideas at a minimal expense, it prompts the necessity for a revaluation of patent policies. Balancing will become all the more difficult if technology progresses in a manner that AI will completely alienate human beings from the inventive process.

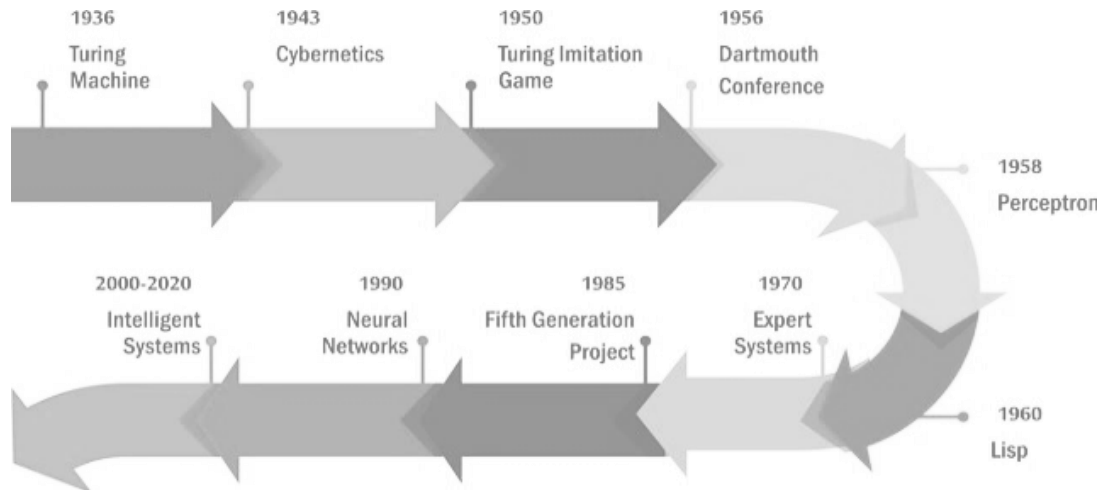
The question of inventiveness under existing patent laws is just one facet of a broader issue. The more critical question is how the emergence of this new invention technology influences our perspective on how the patent system can best fulfil its objectives. AI's emergence has expedited the invention process, reduced costs, and eliminated potential biases stemming from human involvement. The digital revolution, spearheaded by AI, does not just change how production is organized; it fundamentally impacts the invention process itself and, consequently, the incentives for innovation that the patent system seeks to promote.

By addressing the challenges surrounding the inventive-step, this thesis aims to contribute to the ongoing legal debate on the patentability of AI-related inventions. The research findings are expected to provide fresh insights into the balance between encouraging technological progress and maintaining legal certainty, potentially shaping future patent policy and contributing to the refinement of legal standards in response to AI's growing role in the inventive process. Ultimately, this work aspires to influence the broader legal and policy discourse on AI-related inventions, offering a foundation for future debates and helping to ensure that patent law evolves in a manner that remains equitable, robust, and capable of promoting innovation in the AI-driven technological landscape.

B. CONCEPTUAL FOUNDATIONS OF AI

I. Historical Milestones and Definitional Challenges in AI

1. The Rise of AI



Timeline of milestones of AI development⁹

In 1943, Warren McCulloch, a neuroscientist, and Walter Pitts, a logician, developed the first artificial neuron.¹⁰ The first prototypes of neural networks were developed to reproduce the functioning of biological neurons to solve problems, which means the ability of a machine to perform functions and reasoning like the human mind. However, it should be noted that the early neural networks were primarily used for pattern recognition tasks, such as character recognition, rather than general problem solving. The decades following the 1936 Turing machine, an abstract computational model that processes symbols on a tape according to fixed rules and can simulate any algorithm, have been pivotal for the development of today's technology.¹¹ During this time, the first computer programs capable of solving complex problems, particularly games and algorithms to prove theorems of plane geometry, were developed.¹² In 1950, Alan Turing published one of the earliest papers explaining how a computer could emulate human behaviour.¹³ In his papers, Turing introduced the "Imitation Game", now known as the "Turing Test", as a method to assess whether a machine can exhibit intelligence that cannot be distinguished from a human.¹⁴ In the test, a human evaluator (the

⁹ Francisco J Cantu-Ortiz et al., 'An artificial intelligence educational strategy for the digital transformation' (2020) 14(42) *International Journal on Interactive Design and Manufacturing* 1, <https://doi.org/10.1007/s12008-020-00702-8>.

¹⁰ Stuart J Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (3rd edn, Pearson 2010) ch 1.1, § 15.

¹¹ On the 1936 Turing machine: Marvin L Minsky, *Computation: Finite and Infinite Machines* (Prentice-Hall 1967) 107; Michael Sipser, *Introduction to the Theory of Computation* (Course Technology 2006) 137 et seq.

¹² One of the initial instances of a program designed to tackle complex problems is the ENIAC computer, which was created in 1946 and employed during World War II for calculating ballistic trajectories ("ENIAC" (Encyclopaedia Britannica, 2024) <https://www.britannica.com/technology/ENIAC>).

¹³ Alan M Turing, 'Computing Machinery and Intelligence' (1950) 59 *Mind* 433 et seq.

¹⁴ *Ibid*, 442 et seq.

interrogator) engages in a text-based conversation with both a human and a machine, without knowing which is which, and attempts to determine which is the machine based on the responses.¹⁵ If the evaluator cannot distinguish between the two, the machine is considered to have showed human-like intelligence.¹⁶

Turing's contribution to AI has been recognised not only within the context of the fundamentals of computer science, but also in the philosophical debate regarding the potential and limitations of these new thinking machines.¹⁷ He is considered the "father" of AI and defined this discipline as "the science and engineering of making intelligent machines, especially intelligent computer programs".¹⁸

Still, the term "artificial intelligence" was not coined until 1956 by John McCarthy during the Dartmouth Summer Research Project on AI,¹⁹ where pioneers of electrical engineering and information theory convened. This conference is frequently referred to as the launch event of AI as a field.²⁰ At the time, many predicted that machines would match or even surpass human performance within a few decades. However, replicating human skills has proven to be more challenging than anticipated and AI has struggled with unpredictability and context.²¹

Since the development of the first programming languages Lisp (1958-1960) and Prolog (1973), there have been significant advances in mathematical models, hardware research and neural networks.²² AI has also benefited from ideas, perspectives, and techniques borrowed from other fields, such as philosophy, mathematics, and psychology. For example, debates on the nature of intelligence and rationality have their roots in philosophy, while formal logic has played a crucial role in the mathematical modelling of AI.²³ Meanwhile, psychology has contributed to the study of the relationship between knowledge and action. However, the influence of

¹⁵ Graham Oppy and David Dowe, 'The Turing Test' (2021) *The Stanford Encyclopedia of Philosophy* <https://plato.stanford.edu/entries/turing-test/>.

¹⁶ Ibid.

¹⁷ Ray Kurzweil, 'The Coming Merging of Mind and Machine' (Scientific American, 23 March 2009) <https://www.scientificamerican.com/article/merging-of-mind-and-machine>; Alan M Turing, 'Computing Machinery and Intelligence' (1950) 59 *Mind* 433 et seq.

¹⁸ John McCarthy, 'What Is Artificial Intelligence?' (2007) *Stanford University* 2; see also: Daniele Manca and Gianmario Verona, 'Intelligenza non solo artificiale: il potenziale di una tecnologia di cui non siamo ancora davvero consapevoli' (Corriere della Sera, 28 November 2022) https://www.corriere.it/tecnologia/22_novembre_28/intelligenza-non-solo-artificiale-il-potenziale-di-una-tecnologia-di-cui-non-siamo-ancora-davvero-consapevoli-4df0911f-e508-4aaa-9c59-3c7476c6fxlk.shtml.

¹⁹ John McCarthy et al., 'A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence' (1955) <http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf>.

²⁰ Attendees included Claude Shannon, inventor of Information Theory; Nathaniel Rochester, an electronic engineering pioneer; and Marvin Minsky, a Turing Award winner. Their optimism, along with the coining of the term "AI", led to AI research projects at American universities like Stanford and MIT. There was widespread enthusiasm, with some believing that fully intelligent machines could be created within a decade (Daniele Manca and Gianmario Verona, 'Intelligenza non solo artificiale: il potenziale di una tecnologia di cui non siamo ancora davvero consapevoli' (Corriere della Sera, 28 November 2022).

²¹ Daniele Manca and Gianmario Verona, 'Intelligenza non solo artificiale: il potenziale di una tecnologia di cui non siamo ancora davvero consapevoli' (Corriere della Sera, 28 November 2022).

²² Aidan Cuthbertson, 'Artificial Intelligence Program ConceptNet Matches 4-Year-Old Child in IQ Test' (Int'l Business Times, 7 October 2015) <http://www.ibtimes.co.uk/artificial-intelligence-program-conceptnet-matches-4-year-old-child-iq-test-1522836>.

²³ Ibid.

cybernetics and informatics on AI has been particularly notable, paving the way for the formal birth of the field.²⁴

The breakthroughs in the first decades were soon overshadowed by the first failures.²⁵ Methods suitable for simple cases proved to be inadequate in more complex and extensive contexts, as larger problems could not be solved with just faster hardware and larger memories. Inherent limitations in the nature of the problems themselves posed significant challenges.²⁶ The first turning point came in the late 1970s with the development of central process units and graphic processing units. The central process unit is the operational centre of the computer and interprets and processes all incoming information, performing all relevant operations. It is the component that most characterizes the computer and helps to define its performance by allowing for the execution of individual instructions.²⁷ Instead, the video card generates the video signal for the monitor and creates the images on the screen. Due to the increasing complexity and quality of images, animations, and videos, the graphics card has become a critical component, even functioning as a sub-computer. In fact, it has its own processor, called the graphic processing units, and memory. Modern graphic processing units are highly efficient in managing computer graphics and image processing due to their highly parallel structure. Since their invention, both central process unit and graphic processing units have significantly reduced the time required for supervised training of neural networks, meaning the time spent training a neural network to produce the desired output for a given input.²⁸

Since its inception in the early 1950s, the field of AI has undergone significant evolution, branching into three distinct areas of research.²⁹ The first of these areas is rooted in the “symbol processing hypothesis”, a concept initially formulated by *Turing*, whose approach laid the groundwork for subsequent developments in symbolic AI, where intelligence is modelled through the manipulation of symbols and formal logic. The formalisation of this paradigm was further advanced by the physical symbol system hypothesis, articulated by *Newell* and *Simon*, which posits that “a physical symbol system has the necessary and sufficient means for general intelligent action”.³⁰ The second branch that garnered increasing attention over time is robotics, whilst the third stream of research has revolved around the “learning approach”, with particular emphasis on the domain referred to as “machine learning”.³¹ The last branch, machine learning, experienced substantial development and widespread adoption around the mid-2000s, to the

²⁴ Ibid.

²⁵ Yorick Wilks, ‘Machine Translation and Artificial Intelligence’ in B M Snell (ed), *Translating and the Computer* (North-Holland Publishing Company 1979) 29.

²⁶ Ibid.

²⁷ Ibid.

²⁸ John R Searle, ‘Minds, Brains and Programs’ in *The Behavioral and Brain Sciences*, Vol 3 (Cambridge University Press 1980) 417 et seq.

²⁹ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 4, <https://ssrn.com/abstract=3539406>.

³⁰ Allen Newell and Herbert A Simon, ‘Computer Science as Empirical Inquiry: Symbols and Search’ (1976) 19(3) *Communications of the ACM* 116.

³¹ Geoffrey E Hinton and Ruslan R Salakhutdinov, ‘Reducing the Dimensionality of Data with Neural Networks’ (2006) 313 *Science* 504 et seq.

extent that it is frequently regarded as a general-purpose technology.³² In fact, it holds a prominent position as one of the most influential AI technologies in contemporary discourse.³³

2. The Evolution of AI

The current expansion in the field has been made possible by three causes, namely (a) the development of more powerful computing hardware, including graphics processing units and specialized hardware like tensor processing units, (b) the availability of vast amounts of digital data, particularly with the growth of the internet, and (c) the advancements in algorithm design, such as the development of backpropagation for training neural networks.³⁴ Recent technical developments in AI have focused on improving machine learning algorithms, expanding the capabilities of neural networks, enhancing natural language processing and generation, developing more advanced robotics, and advancing AI. These technical developments have the potential to revolutionise industries, ranging from healthcare to finance, and continue to drive innovation and progress in the field of AI.

AI is nowadays quite widespread, yet due to its intangible nature, it often operates as the hidden engine behind products and services. Its presence may be suspected, but it is rarely directly observable.³⁵ To mention just a few applications in the last decade, Google implemented “Duplex”,³⁶ a system capable of holding telephone conversations with human users, processing complex answers in real time using natural language, without the interlocutor realising they were speaking to a machine.³⁷ In the retail sector, Amazon has employed AI to anticipate consumer needs, aiming to identify user preferences before the users themselves become aware of them, sometimes by offering highly personalised incentives or discounts.³⁸ This is accomplished through user profiling based on browsing activity and previous purchases.³⁹ Netflix has similarly relied on machine learning algorithms to suggest content tailored to

³² Nonetheless, it is essential to acknowledge the relevance of other AI technologies, such as evolutionary algorithms, which continue to be of significance within the broader landscape of AI research and application. See Section B.II.2.

³³ One essay stands out for providing a comprehensive overview of the technical and legal issues in their entirety: Daniel Ben-Ari and others, ‘Danger, Will Robinson? Artificial Intelligence in the Practice of Law: An Analysis and Proof of Concept Experiment’ (2017) 23(2) *Richmond Journal of Law & Technology* 3 et seq.

³⁴ Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 493; see also: Peter R Slowinski, ‘Artificial Intelligence, Novelty and Inventive Step: What Is the Impact of AI on Patent Law?’ in Z Sikorski and J Zemła-Pacud (eds), *Patents as an Incentive for Innovation* (Wolters Kluwer, Alphen aan den Rijn 2021); and Xin Yang et al., ‘Concepts of Artificial Intelligence for Computer-Assisted Drug Discovery’ (2019) 119 *Chemical Reviews* 10523 <https://doi.org/10.1021/acs.chemrev.8b00728>.

³⁵ Timothy B Lee, ‘Artificial Intelligence Is Getting More Powerful, and It’s About to Be Everywhere’ (Vox, 18 May 2017) <https://www.vox.com/new-money/2017/5/18/15655274/google-io-ai-everywhere>.

³⁶ Google Duplex is a feature of Google Assistant that was introduced by the company at Google I/O 2018.

³⁷ Yaniv Leviathan and Yossi Matias, ‘Google Duplex: An AI System for Accomplishing Real-World Tasks Over the Phone’ (Google AI Blog, 8 May 2018) <https://research.google/blog/google-duplex-an-ai-system-for-accomplishing-real-world-tasks-over-the-phone/>.

³⁸ Jaydevs, ‘How Amazon Uses AI in eCommerce and Retail? Learn From a Trillion-Dollar-Worth Company’ (13 October 2022) <https://jaydevs.com/how-amazon-uses-ai-in-e-commerce-and-retail/>; for further information see also: <https://aws.amazon.com/machine-learning/what-is-ai/>.

³⁹ WIPO, *WIPO Technology Trends 2019: Artificial Intelligence* (WIPO 2019) 19.

individual viewing behaviour.⁴⁰ Target's deployment of predictive analytics once led to a now well-known incident in which its algorithm inferred a teenage girl's pregnancy based on her purchasing patterns, resulting in her receiving pregnancy-related advertisements at home before informing her family.⁴¹ This raised widespread concerns about privacy and the ethical use of data, leading the company to revise its targeting strategies.⁴² Over the last couple of years, AI systems have become significantly more advanced and widespread. Large language models (LLMs), which are a mathematical representation of a language,⁴³ such as OpenAI's Generative Pre-trained Transformers (GPT)-based systems, are now capable of generating coherent text, answering complex queries, and even writing code.⁴⁴ Multimodal models like OpenAI's Sora and Google's Gemini integrate visual, textual, and auditory inputs to generate rich outputs, including images and video.⁴⁵ AI-powered autonomous agents are now routinely deployed in areas such as healthcare, legal services, and customer support, performing tasks that once required substantial human involvement.⁴⁶ These developments mark a clear shift from narrow, task-specific applications towards more general-purpose and deeply embedded AI systems.

Despite significant progress, not all recent developments in AI have been positive. While many systems demonstrate advanced problem-solving capabilities, concerns persist regarding their potential to perpetuate bias and misinformation. Earlier versions of OpenAI's language models, for example, were shown to generate conspiracy theories, such as denying the moon landing, raising questions about model reliability.⁴⁷ Similarly, the 2019 controversy surrounding the Apple Card's credit algorithm, accused of gender bias, highlighted the risks of opaque and discriminatory decision-making.⁴⁸ These cases underscore the importance of transparency,

⁴⁰ Massimiliano Craglia, Alessandro Annoni et al., *Artificial Intelligence - A European Perspective* (EUR 29425 EN, Publications Office, Luxembourg 2018) 27.

⁴¹ The original story was reported by Charles Duhigg in *The New York Times Magazine* (Charles Duhigg, 'How Companies Learn Your Secrets' *The New York Times* (New York, 16 February 2012) <https://www.nytimes.com/2012/02/19/magazine/shopping-habits.html>) and later in his book Charles Duhigg, *The Power of Habit* (Random House 2012).

⁴² Charles Duhigg, 'How Companies Learn Your Secrets' *The New York Times* (New York, 16 February 2012).

⁴³ Daria Kim, 'On Words That Come Easy' (2023) *GRUR International* 1 et seq. <https://doi.org/10.1093/grurint/ikad030>; Melissa Heikkilä and Will Douglas Heaven, 'What's Next for AI' (MIT Technology Review, 2022).

⁴⁴ OECD, *Artificial Intelligence in Science: Challenges, Opportunities and the Future of Research* (OECD Publishing 2023) 22 et seq.; Katikapalli Subramanyam Kalyan, 'A Survey of GPT-3 Family Large Language Models Including ChatGPT and GPT-4' (2023) *arXiv* 10 et seq.

⁴⁵ Yixin Liu et al., 'Sora: A Review on Background, Technology, Limitations, and Opportunities of Large Vision Models' (2024) *arXiv* 2 et seq.; Rohan Anil et al., 'Gemini: A Family of Highly Capable Multimodal Models' (2025) *arXiv* 1 et seq.

⁴⁶ See for example: Alaa Abd-alrazaq et al., 'Large Language Models in Medical Education: Opportunities, Challenges, and Future Directions' (2023) 9 *JMIR Medical Education* 3 et seq; Brian Gormley, 'Companies Bring AI Agents to Healthcare' (*The Wall Street Journal*, 27 February 2025).

⁴⁷ In this way the texts generated independently by the system were carriers of fake news, which readers could hardly distinguish from texts written by 'real' humans. It is in fact not the first time in history that humans have been frightened by their own technological creations. In 1888, Thomas Edison designed the electric chair to demonstrate the dangers of alternating current, a technology defended by his competitor Nikola Tesla. The first execution was a disaster: William Kemmler died in unbearable suffering. The campaign to demonize electricity was also powered by John D Rockefeller who rightly glimpsed the end of his diesel lighting of cities. But, precisely, in those cases they were mainly trade wars for the supremacy of standards. (Massimo Sideri, 'Il robot che poteva ingannarci tutti' (*Corriere della Sera*, 16 February 2019) 15).

⁴⁸ Goldman Sachs denied any discrimination and stated that their credit decisions were based on an individual's creditworthiness, regardless of their gender or any other demographic characteristic. The incident did lead to increased scrutiny of the use of AI in financial decision-making and calls for greater transparency and accountability in the use of algorithms. The New York Department of Financial Services concluded that the

fairness, and regulatory oversight in the design and deployment of AI systems.⁴⁹ As machines increasingly shape outcomes in finance, healthcare, and law, embedding ethical reasoning into their operation remains a critical challenge.⁵⁰ While techniques like reinforcement learning with human feedback aim to reduce bias, they rely on diverse data and continual human oversight. Building inclusive and accountable AI requires not only technical refinement but also sustained ethical and regulatory engagement.⁵¹

3. The Attempt at a Unitary Definition

The definitions of AI can vary based on the specific purpose, field, subject matter, and other factors relevant to the AI system under consideration.⁵² In modern dictionary there are countless different definitions of AI.⁵³ Oxford Languages defines AI as “the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages”.⁵⁴ According to Encyclopaedia Britannica AI is the “ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings”.⁵⁵ Merriam-Webster instead defines AI as “1) a branch of computer science dealing with the simulation of intelligent behaviour in computers. 2) the capability of a machine to imitate intelligent human behaviour”.⁵⁶ From an informatics standpoint, AI can be described as the discipline that encompasses the theories and practical techniques for developing algorithms that enable machines to carry out intelligent activities.⁵⁷ In the computer industry, AI is the discipline that focuses on creating machines, both hardware and software, able to “act” autonomously and

algorithm did not discriminate against women in credit decisions. However, the investigation did reveal that the algorithm had “significant disparities” in credit limits for women compared to men, which led to Goldman Sachs revising its credit limit determination process. (Ian C Campbell, ‘The Apple Card Doesn’t Actually Discriminate Against Women, Investigators Say’ (The Verge, 24 March 2021) <https://www.theverge.com/2021/3/23/22347127/goldman-sachs-apple-card-no-gender-discrimination>).

⁴⁹ Liz O’Sullivan, ‘How the law got it wrong with Apple Card’ (TechCrunch, 14 August 2021) <https://techcrunch.com/2021/08/14/how-the-law-got-it-wrong-with-apple-card/>.

⁵⁰ Tim Fountaine, Brian McCarthy and Tamim Saleh, ‘Building the AI-Powered Organization’ (2019) 97 *Harvard Business Review* 63 et seq.

⁵¹ Francesca Bria, ‘C’è una via etica alla IA: il nostro Claude più umano di ChatGpt’ (La Repubblica, 27 April 2023).

⁵² Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 6, <https://ssrn.com/abstract=3619069>.

⁵³ Bernard Marr, ‘The Key Definitions of Artificial Intelligence (AI) That Explain Its Importance’ (Forbes, 14 February 2018) <https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/?sh=56e9e3494f5d>.

⁵⁴ Lexico, ‘Artificial Intelligence’ https://www.lexico.com/definition/artificial_intelligence.

⁵⁵ Encyclopaedia Britannica, ‘Artificial Intelligence’ <https://www.britannica.com/technology/artificial-intelligence>.

⁵⁶ Merriam-Webster, ‘Artificial Intelligence’ <https://www.merriam-webster.com/dictionary/artificial%20intelligence>.

⁵⁷ AI, though challenging to precisely define, encompasses intricately designed information systems that have witnessed substantial growth in their capabilities, primarily attributed to the rapid progression of machine learning, particularly within the domain of deep learning (Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in R Lee, P Hilty and L Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 99; Ana P Gonzalez Torres, ‘AI-generated inventions: (A)I, inventor?’ (IusItinere, 27 April 2022) https://www.iusinitinere.it/ai-generated-inventions-ai-inventor-42263#_ftn9; Josef Bajada, ‘Artificial Intelligence Demystified’ (Towards Data Science, 2019), <https://towardsdatascience.com/https-medium-com-josef-bajada-demystifying-artificial-intelligence-6f5f7a8dd1b0>).

solve problems or take actions based on a specific context or scenario. Devices with integrated AI are interactive, autonomous, and adaptable. They respond to stimuli, act without human input, and improve their performance by adjusting the rules that govern their operation.⁵⁸ Unlike traditional algorithms with fixed behaviours, machine learning enables these devices to learn from new data and evolve their actions, accordingly, making them more dynamic, but also less predictable, over time.⁵⁹

While the term “artificial” encompasses everything that is not naturally occurring, the interpretation of “intelligence” appears to be a subject of division amongst scholars.⁶⁰ At its core, AI is a branch of computer science dedicated to the study and development of systems capable of performing tasks that typically require human intelligence, such as reasoning, learning, and decision-making.⁶¹ Finding a definition poses not only semantic problems, but the evolving nature of AI also makes it difficult to find a standard definition that remains fitting over time.

The combination of the words “artificial” and “intelligence” generally refers to the ability of a high-tech system to solve problems or perform tasks that are characteristic of human intelligence.⁶² On the one hand, according to *Russell* and *Norvig*, AI is defined by the ability to perform some actions and functions that are typically associated with humans. These include acting humanly (without distinction from an actual human), thinking humanly (solving problems using cognitive functions), thinking rationally (exploiting logic as a human being does), and acting rationally (initiating a process to achieve the best expected result based on available information, which is what humans often do unconsciously).⁶³ On the other hand, according to *Kaplan*, AI should not be stereotyped as a humanoid being with attributes similar to those of a human, nor should it be considered as a replacement for the human brain.⁶⁴ Rather, AI should be understood as a set of algorithms that process vast amounts of data and provide answers based on statistical analysis. AI is not only used in physical machines, but it also powers fully automated processes that gather and analyse information to produce outcomes and make adjustments. These algorithms can influence the real world and interact with people,

⁵⁸ Stuart J Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (3rd edn, Pearson 2010), ch 1.1, 22.

⁵⁹ Pamela Samuelson, ‘Benson Revisited: The Case Against Patent Protection for Algorithms and Other Computer Program-Related Inventions’ (1990) 39 *Emory LJ* 1025.

⁶⁰ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 26-27; “artificial, adj. and n.”, *Oxford English Dictionary Online* (OUP 2023) <https://www.oed.com/view/Entry/11125>; Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 22 (the Author however stresses that the boundaries between natural and artificial might be thinning).

⁶¹ Herbert A Simon, ‘Artificial Intelligence: An Empirical Science’ (1995) 77(1) *Artificial Intelligence* 95 et seq.; Peter Stone et al., ‘Artificial Intelligence and Life in 2030: One Hundred Year Study on Artificial Intelligence: Report of the 2015–2016 Study Panel’ (Stanford University, September 2016) <https://ai100.stanford.edu/2016-report>.

⁶² George F Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving* (6th edn, Pearson 2008); Wodrow Hartzog et al., ‘Inefficiently Automated Law Enforcement’ (2015) *Michigan State Law Review* 1765-68 and 1793-95.

⁶³ Stuart J Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (3rd edn, Pearson 2010); David L Poole and Alan K Mackworth, *Artificial Intelligence: Foundations of Computational Agents* (Cambridge University Press 2010).

⁶⁴ Jerry Kaplan, *Intelligenza artificiale: Guida al futuro prossimo* (Luiss 2017) 15.

sometimes even acting in place of human decision-making, though their actions are still shaped by the intentions of those who design and use them.⁶⁵

Still, the question remains as to whether the term “intelligence” accurately applies to machines or if it should be exclusively reserved for humans. Human intelligence encompasses various cognitive abilities, such as thinking, attributing meaning to actions, experiencing emotions, laughing, and possessing self-awareness, whilst machines do not possess a genuine understanding. They lack the capability to comprehend semantics or exhibit intentionality, aspects that humans possess. However, recent developments demonstrate machines’ emerging ability to simulate understanding, exemplified by ChatGPT. This advancement relies on the concept of a semantic network, often referred to as the 3.0 network, enabling machines to simulate the process of comprehension. When posed with questions, ChatGPT provides responses that mimic an understanding of the intended meaning, thus appearing to grasp the essence of the inquiry.⁶⁶

Moving beyond the impasse regarding the definition of “intelligence”, a noteworthy approach is the one followed by *Yanisky-Ravid* and *Jin* that identifies eight essential characteristics of AI systems: (a) creative, (b) unpredictable, (c) independent and autonomous, (d) rational, (e) evolving, (f) capable of gathering and communicating data, (g) efficient and accurate, and (h) able to make decisions among various options.⁶⁷ These eight features provide the foundation for a flexible and balanced framework to identify AI systems as inherently and functionally complex. Even if only some of these features are present, a computer system may still be classified as AI or AI-like.⁶⁸

A similar approach has been followed by the High-Level Expert Group on Artificial Intelligence, established by the European Commission, that offered a definition of AI centred around its functionalities.⁶⁹ According to the final version of the EU AI Act that entered into

⁶⁵ Erica Fraser, ‘Computers as Inventors - Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 305 <https://script-ed.org/article/computers-as-inventors-legal-and-policy-implications-of-artificial-intelligence-on-patent-law/>.

⁶⁶ The fast progress of generative AI prompts the question as to why robots have not progressed at the same speed. Contrary to traditional assumptions, high-level reasoning requires very little computation, whereas low-level sensorimotor and perceptual abilities require enormous computational resources. *Moravec* argues that it is relatively easy to make computers perform at an adult level in intelligence tests or in playing chess, but it is difficult or even impossible to give them the skills of a one-year-old child when it comes to perception and mobility. In other words, activities that are complicated for humans, such as finding the cube root of a very large number, are easy for computers and AI, while simple sensory and motor skills for an infant, like manipulating an object or opening a door by turning the handle, are incredibly complex for current computers and AI systems. There are several explanations given for the so-called *Moravec’s* paradox. Evolutionists argue that human sensorimotor abilities are the result of millions of years of evolution and are therefore mostly unconscious. The large sensory and motor portions of the human brain contain millions of years of experience in perceiving the world and the skills needed to survive in it (Paolo Benanti, ‘La domanda: perché le A.I. sono così avanzate mentre i robot non hanno avuto lo stesso sviluppo?’ (Corriere della Sera, 7 July 2023) https://www.corriere.it/sette/attualita/23_luglio_07/domanda-perche-ai-sono-cosi-avanzate-mentre-robot-non-hanno-avuto-stesso-sviluppo-4c9d5f3c-1a66-11ee-803d-db3b1d875840.shtml).

⁶⁷ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 6.

⁶⁸ *Ibid.*

⁶⁹ High-Level Expert Group on Artificial Intelligence, ‘A Definition of AI: Main Capabilities and Disciplines’ (2019) 6 <https://digital-strategy.ec.europa.eu/en/library/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines>.

force on 1 August 2024, an AI system is defined as “a machine-based system designed to operate with varying levels of autonomy, that may exhibit adaptiveness after deployment and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments.”⁷⁰ This definition corresponds to the definition of the Organization for Economic Cooperation and Development and will be used as the operative definition for the purposes of this work.⁷¹

Although this use of an internationally developed and recognized definition can promote its acceptance and harmonization,⁷² in terms of AI-related inventions the challenge of a unitary definition is further complicated by the lack of supplementary definitions. There still is a prevalence of ambiguous terms as “autonomous” and “tool” frequently employed to describe the capabilities and functions of AI systems.⁷³ Some scholars argue that the lack of a definition of such terms makes it difficult to determine the patentability of AI-related inventions,⁷⁴ given the difficulties to distinguish whether the AI system generates or assists.⁷⁵ This issue will be explored in further depth later in this work, where an attempt will be made to define ambiguous terms and address the challenges they pose to the patentability of AI-related inventions.

4. Preliminary Results

The conceptual foundations of AI trace their roots back to key milestones in the development of computing and neuroscience. The first artificial neuron, developed by Warren McCulloch and Walter Pitts in 1943, marked the beginning of neural networks, though these early systems were limited to tasks like pattern recognition rather than broader problem-solving capabilities. The theoretical underpinnings of AI were further advanced by Alan Turing’s work in the 1950s, particularly through his introduction of the Turing Test, which explored whether a machine could emulate human behaviour. Despite AI’s formal inception in 1956 at the Dartmouth Summer Research Project on AI, early expectations that machines would quickly match or surpass human performance were overly optimistic.

Subsequent decades saw significant progress with the development of programming languages such as Lisp and Prolog, and the integration of ideas from various fields, including mathematics, philosophy, and psychology. However, AI faced significant challenges, particularly in scaling from solving small, simple problems to tackling larger, more complex tasks. It was not until the late 1970s, with the advent of more powerful central processing units and graphical processing

⁷⁰ ‘Article 3: Definitions’ (n 6).

⁷¹ OECD AI Policy Observatory, ‘Definition of AI’ (6 March 2024) <https://oecd.ai/en/work/definition>.

⁷² Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 7.

⁷³ Ryan Abbott and Elizabeth Rothman, ‘IP Law in the Era of Generative AI’ (2024) 36(8) *Cutter Journal* 35 <https://www.cutter.com/article/ip-law-era-generative-ai>.

⁷⁴ Jerry Kaplan, *Intelligenza artificiale: Guida al futuro prossimo* (Luiss 2017) 31.

⁷⁵ WIPO, ‘WIPO Conversation on Intellectual Property and Artificial Intelligence’ (January 2020) https://www.wipo.int/meetings/en/doc_details.jsp?doc_id=499504.

units, that the training of neural networks became more efficient, allowing for more rapid progress.

Over time, AI has evolved into a general-purpose technology, widely integrated into applications like natural language processing, autonomous agents, and personalized recommendation systems. Despite these advances, challenges remain regarding AI's unpredictability, ethical use, and bias, as exemplified by incidents involving privacy and algorithmic discrimination. Efforts to embed fairness and transparency continue alongside technical improvements.

As AI continues to evolve, there is no universal definition of the term. While “artificial” refers to non-natural systems, the interpretation of “intelligence” remains a matter of debate. The lack of a clear definition of key terms such as “autonomous” and “tool” complicates the determination of AI's legal status, especially regarding the patentability of AI-related inventions. According to the EU AI Act, an AI system is defined as “a machine-based system designed to operate with varying levels of autonomy, that may exhibit adaptiveness after deployment and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments”.

II. An Overview of AI Technologies and Their Application

1. Basic Concepts of AI and its Subtypes

AI is complex to understand, and the technical working mechanism exceeds the scope of this work. Still, for a better understanding of AI-related inventions, a few basic concepts will be outlined in this Section. Although the term AI is commonly used and will also be used for the scope of this work as a general “umbrella” term, it has various subfields, amongst others the most promising to generate AI-related inventions are: machine learning, artificial neural networks, evolutionary algorithms, deep learning, generative and inventive AI.⁷⁶ In the context of AI-related inventions, the term AI typically involves a combination of these technologies.⁷⁷ For example, a drug developed through AI might involve data collection from smart sensors, cloud-based storage, analysis by deep learning algorithms that learn and adapt through experience, generative AI to propose novel molecular structures and machine learning models to predict drug efficacy and potential side effects.

AI can be described as both a set of tools and the toolbox or machine itself, making it applicable in different settings and for various purposes. Different tools and data can be applied in different ways to generate the desired outcome, but what they usually have in common is that they are

⁷⁶ OpenAI, *A Comparative View of AI, Machine Learning, Deep Learning, and Generative AI* (2023) <https://openai.com/research/comparative-view-ai-ml-dl-generative-ai>.

⁷⁷ Francesca Mazzi, ‘Patentability of AI Generated Drugs’ (2020) 4(1) *EPLR* 17-18.

based on algorithms and models.⁷⁸ An algorithm is a set of instructions that a machine follows to perform a task repeatedly, allowing it to learn how to do the task autonomously. The specific instructions of the algorithm determine what functions are performed with the data supplied by the machine. By analysing data, the algorithm creates a model that shows the patterns and relationships within the data it analysed.⁷⁹

As an analogy, AI can be compared to a culinary process, where data represents the ingredients, and the model represents the recipe for a dish. Just as both (quality) ingredients and a recipe are essential for creating a delicious meal, (quality) data and a model are crucial for AI systems. While the focus is often on designing the recipe (model), the outcome heavily relies on the availability and quality of the ingredients (data).⁸⁰ The generated output is based on massive quantities of high-quality, clean and representative data that makes it valuable to inform decisions about some unknown or hypothetical circumstances or conditions. Furthermore, the recipe (model) is not a fixed entity but rather constantly being developed and refined, emphasizing the need for a more flexible notion of AI. If the task is too complex to program the machine accordingly, reinforcement learning is adopted. This means that the machine interacts with the environment and learns through a process of trial and error. When an action leads to a process it is rewarded and the machine memorises it at such.

a) Machine Learning

One of the current most promising techniques in computer science is machine learning, which consists in the creation of algorithms that lead the software to learn from experience. While over the years software has proven to be effective and efficient when it comes to executing a series of instructions and calculations faster than humans, when a long list of conditions defined *a priori* is not enough to solve a complex problem, machine learning techniques are used.⁸¹

Domingos compares machine learning to farming, stating that learning algorithms are the seeds, data is the soil, and the learned programs are the grown plants. The machine learning expert is like a farmer, sowing the seeds, irrigating and fertilizing the soil, and keeping an eye on the health of the crop but otherwise staying out of the way.⁸²

⁷⁸ Hanan Khalil, Daniel Ameen and Armita Zarnegar, 'Tools to Support the Automation of Systematic Reviews: A Scoping Review' (2022) 144 *Journal of Clinical Epidemiology* 22-42 <https://doi.org/10.1016/j.jclinepi.2021.12.005>.

⁷⁹ Kasia Borowska, 'He: What, How and Why of AI – Part 3' (Forbes, 3 November 2020) <https://www.forbes.com/sites/kasiaborowska/2020/11/03/he-what-how-and-why-of-ai--part-3/?sh=741aad6c6a15>.

⁸⁰ Although the origin of this analogy is unknown, it was debated and further elaborated during a PhD Literature Seminar held by Prof. Joseph Drexler at the MPI, 23 June 2023.

⁸¹ Nahla Davies, 'How To Calculate Algorithm Efficiency' (KDnuggets, September 2022) <https://www.kdnuggets.com/2022/09/calculate-algorithm-efficiency.html>; for a more general discussion see: David Poole, Alan K Mackworth and Randy Goebel, *Computational Intelligence: A Logical Approach* (OUP 1998).

⁸² Pedro Domingos, *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World* (Basic Books 2015) 23.

Unlike traditional rule-based programming, machine learning models are trained to learn the right rules to solve a problem from a set of instructions and data. The difference between deep learning, another commonly used technique and subfield of AI, and machine learning is the learning mode of each algorithm.⁸³ Whilst deep learning automates the feature extraction process, eliminating some of the human intervention and allowing the use of larger datasets, machine learning, on the contrary, is more dependent on human experts to determine the feature set that will enable the algorithm to learn the differences between data inputs. Still, in machine learning the algorithm is not programmed to act in a specific way, but rather to discover patterns in the data it is fed and modify their behaviour, accordingly, making the quality of the data extremely relevant to the outcome.⁸⁴

Machine learning can be seen as a “general-purpose” technology due to its vast applicability.⁸⁵ It can be likened to research tools as they serve as valuable inputs for driving innovation activities.⁸⁶ It is often described as a way to mimic the way humans learn, with the aim of gradually improving accuracy, thus a key technology in the advancement of AI.⁸⁷

b) Artificial Neural Networks

Artificial neural networks are a subset of machine learning and are the core element of deep learning algorithms.⁸⁸ They are inspired by the human brain, imitating the way biological neurons send signals to each other.⁸⁹ They mirror the behaviour of the human brain, enabling computer programs to recognise patterns and solve common problems in the field of AI.⁹⁰

Artificial neural networks consist of multiple layers of nodes that contain an input layer, one or more hidden layers and an output layer.⁹¹ Each node, or artificial neuron, connects to another and has an associated weight and threshold. If the output of any individual node is above the

⁸³ IBM Data and AI Team, ‘AI vs. Machine Learning vs. Deep Learning vs. Neural Networks: What’s the Difference?’ (IBM, 6 July 2023) <https://www.ibm.com/think/topics/ai-vs-machine-learning-vs-deep-learning-vs-neural-networks>; see also: Josef Drexl et al., ‘Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective’ (MPI Research Paper No. 19-13, 10 October 2019) 11 et seq.

⁸⁴ David Lehr and Paul Ohm, ‘Playing with the Data: What Legal Scholars Should Learn About Machine Learning’ (2017) 51 *U.C. Davis Law Review* 677.

⁸⁵ Fumo, Jose, ‘Types of Machine Learning Algorithms You Should Know’ (Towards Data Science, 2020) <https://towardsdatascience.com/types-of-machine-learning-algorithms-you-should-know-953a08248861>.

⁸⁶ Josef Drexl et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 2021) 21 et seq.

⁸⁷ IBM, ‘What is Machine Learning?’ <https://www.ibm.com/it-it/cloud/learn/machine-learning>.

⁸⁸ On the evolution of these technologies see: Varun Nigam, *Understanding Neural Networks: From Neuron to RNN, CNN, and Deep Learning* (Towards Data Science, 11 September 2018) <https://towardsdatascience.com/understanding-neural-networks-from-neuron-to-rnn-cnn-and-deep-learning-cd88e90e0a9>.

⁸⁹ Matt Taddy, ‘The Technological Elements of Artificial Intelligence’ (NBER Working Paper No. 24301, 2018), 8 et seq. <https://www.nber.org/papers/w24301.pdf>.

⁹⁰ Josef Drexl et al., ‘Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective’ (MPI Research Paper No. 19-13, 10 October 2019) 11.

⁹¹ As early as 1958, Frank Rosenblatt created his perceptron algorithm for supervised learning in binary classification tasks. On the introduction of the neural network see: Frank Rosenblatt, *The Perceptron: A Theory of Statistical Separability in Cognitive Systems* (Project Para) (Cornell Aeronautical Laboratory 1958).

specified threshold value, that node is activated, sending data to the next layer in the network.⁹² Otherwise, no data is passed to the next network layer.⁹³ Artificial neural networks can be understood mathematically as a set of matrix operations and finding derivatives.⁹⁴

An untrained neural network is versatile and can be applied to a broad range of tasks without being restricted to any particular one.⁹⁵ The specific limitations are introduced during the training process, where various parameters interact. In essence, the training process entails altering the fundamental structure of the neural network and customizing it for a specific task, which involves changing the underlying mathematical function.⁹⁶ From a mathematical perspective, this training process can be conceptualized as a matrix multiplication.⁹⁷

Artificial neural networks rely on training data, which are data used for training an AI system through fitting its learnable parameters, including the weights of a neural network.⁹⁸ This way, neural networks learn and improve their accuracy over time. Once optimised, these learning algorithms are powerful tools in computer science and AI, able to classify data at high speed.⁹⁹ A trained neural network can be thought of as an “expert” in the category of information it has been given to analyse.¹⁰⁰

They are used in a variety of applications. One example is AlphaZero, which achieved impressive results by using a neural network to learn how to play games like chess and shogi entirely through self-play.¹⁰¹ Another noteworthy application of neural networks is *Thaler’s* “Creativity Machine”, which uses two interacting networks to design innovative products such as the Oral-B cross-bristle toothbrush.¹⁰² The machine allegedly came up with the idea of crossed bristles for optimal toothbrush functionality, after being given information about the characteristics and performance of existing toothbrushes, 2.000 possible designs, many of them with crossed bristles.¹⁰³ Although it was still a human that posed the problem, provided the

⁹² Stuart J Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (3rd edn, Pearson Education 2016) 729.

⁹³ IBM, ‘Neural Networks’ <https://www.ibm.com/it-it/cloud/learn/neural-networks>.

⁹⁴ WIPO, ‘Background Document on Patents and Emerging Technologies’ (2019) 9 www.wipo.int/edocs/mdocs/scp/en/scp_30/scp_30_5.pdf.

⁹⁵ Oskar Paulini, ‘Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz’ (PhD thesis, LMU Munich 2023) 23 <https://edoc.ub.uni-muenchen.de/32033/>.

⁹⁶ Josef Drexler et al., ‘Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective’ (MPI Research Paper No. 19-13, 10 October 2019) 7.

⁹⁷ Tariq Rashid, *Neuronale Netze selbst programmieren: ein verständlicher Einstieg mit Python* (O’Reilly 2017) 44 et seq.

⁹⁸ European Commission, ‘Article 3: Definitions’ <https://artificialintelligenceact.eu/article/3/#:~:text=This%20article%20provides%20definitions%20for,outputs%20like%20predictions%20or%20decisions>.

⁹⁹ William Di et al., *Deep Learning Essentials: Your Hands-on Guide to the Fundamentals of Deep Learning and Neural Network Modeling* (Packt Publishing Birmingham 2018) 87; Michael Wooldridge, *The Road to Conscious Machines* (Pelikan 2020) 188.

¹⁰⁰ Christos Stergiou and Dimitrios Siganos, ‘Artificial Neural Network in Medicine’ (2014) <http://www-students.doc.ic.ac.uk/~cbp/article2.htm>.

¹⁰¹ David Silver et al., ‘A General Reinforcement Learning Algorithm Masters Chess, Shogi and Go Through Self-Play’ (2019) *Science* 362, 1140-1144.

¹⁰² Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 315; Imagination Engines Inc., ‘IEI’s Patented Creativity Machine® Paradigm’; US Patent No. 5,659,666 (issued 12 August 1997).

¹⁰³ Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed - A Journal of Law, Technology & Society* 315.

machine with the data and made the decisive selection on the hypotheses provided, the relevance of these acts can be debated, especially in the evaluation of the origin of the inventive step. *Thaler* also created the beforementioned sophisticated AI model DABUS, which combines multiple artificial neural networks and has been cited as the supposed inventor in several patent applications.¹⁰⁴ In DABUS, an acronym for “Device for the Autonomous Bootstrapping of Unified Sentience”, two artificial neural networks work together: the first generates new content, the second evaluates it for novelty.¹⁰⁵ With two months of training, *Thaler* claims to have transformed DABUS from a machine that mainly produces art, into an inventor’s AI.¹⁰⁶ However, the extent to which these neural networks can truly exhibit inventive abilities is the subject of considerable debate in the legal literature.¹⁰⁷

c) Evolutionary Algorithms

One of the subfields of AI that is increasingly used in research and development and particularly interesting in terms of AI-related inventions, are evolutionary algorithms.¹⁰⁸ These algorithms are stochastic search algorithms that are similar to *Darwin’s* theory of survival of the fittest, operating by creating a group of potential solutions to a problem and evaluating each one’s fitness against specific criteria. The most successful solutions are selected and used to produce a new generation of potential solutions through mutations or crossovers, until a solution is found.¹⁰⁹ Unlike data-intensive machine learning techniques that depend on the quality of the submitted data, evolutionary algorithms do not function on the same principles and solve complex optimization problems without requiring extensive training data.¹¹⁰

¹⁰⁴ Imagination Engines Inc., ‘DABUS Described’ <https://imagination-engines.com/dabus.html>; Artificial Inventor Project, <https://artificialinventor.com/>.

¹⁰⁵ Martin Coulter, ‘Patent agencies challenged to accept AI inventor’ (Financial Times, 1 August 2019) <https://www.ft.com/content/9c114014-b373-11e9-bec9-fdcab53d6959>; Leo Kelion, ‘AI System “Should Be Recognized as Inventor?”’ (BBC, 1 August 2019); Dan Robitzski, ‘Scientists Are Trying to List AI as the Inventor on a New Patent’ (Futurism, 2 August 2019) <https://futurism.com/scientists-ai-inventor-patent>.

¹⁰⁶ Thaler characterizes DABUS as a “Creativity Engine” that can produce “novel ideas” and then evaluate their originality by comparing them to existing ideas within its database (George Dvorsky, ‘Should Artificial Intelligence Be Credited as an Inventor?’ (Gizmodo, 2 August 2019) <https://gizmodo.com/should-artificial-intelligence-be-credited-as-an-invent-1836920203>).

¹⁰⁷ Mark Summerfield, ‘The Impact of Machine Learning on Patent Law, Part 2: Machine-Assisted Inventing’ (Patentology, 21 January 2018) <https://blog.patentology.com.au/2018/01/the-impact-of-machine-learning-on-21.html>; Daria Kim et al., ‘Artificial Intelligence Systems as Inventors? A Position Statement of 7 September 2021 in view of the evolving case-law worldwide’ (MPI Research Paper No. 21-20, 2021) 1 et seq. <https://ssrn.com/abstract=3919588>.

¹⁰⁸ John R Koza, ‘Human-Competitive Results Produced by Genetic Programming’ (2010) 11 *Genetic Programming and Evolvable Machines* 251 <https://doi.org/10.1007/s10710-010-9112-3>; Peter R Slowinski, ‘Artificial Intelligence, Novelty and Inventive Step: What Is the Impact of AI on Patent Law?’ in Z Sikorski and J Zemła-Pacud (eds), *Patents as an Incentive for Innovation* (Wolters Kluwer, Alphen aan den Rijn 2021) 256.

¹⁰⁹ Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 451 <https://doi.org/10.1093/grurint/ikaa061>; Josef Drexl et al., ‘Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective’ (MPI Research Paper No. 19-13, 10 October 2019) 11.

¹¹⁰ Josef Drexl et al., ‘Comments of the MPI of 11 February 2020 on the Draft Issues Paper of the WIPO on Intellectual Property Policy and Artificial Intelligence’ (2020) 2 https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/2020-02-11_WIPO_AI_Draft_Issue_Paper_Comments_Max_Planck.pdf; Peter R Slowinski, ‘Artificial Intelligence,

Generally speaking, the type of data that is useful to an AI algorithm depends on the specific problem the algorithm is trying to solve, and the type of AI model being used.¹¹¹ AI algorithms require a large amount of diverse and representative data to be trained on in order to learn patterns and make predictions. This data is often referred to as “training data”. In some cases, “big data” can be particularly useful for AI algorithms, as it provides a vast amount of information for the algorithm to learn from.¹¹² For example, in fields such as natural language processing, image recognition and speech recognition, big datasets can provide a diverse range of examples for the algorithm to learn from, helping to improve its accuracy and ability to generalize to new situations.¹¹³ The existence of large quantities of data is due to technologies that are able to transform multiple phenomena of the material world into data.¹¹⁴ However, not all AI problems require “big data”.¹¹⁵ In some cases, smaller datasets can still be used to train effective AI models, especially if the data is high quality and well-curated. Ultimately, the usefulness of data for an AI algorithm depends on several factors, including the size of the dataset, the diversity and representativeness of the data, and the quality of the data.¹¹⁶

Evolutionary algorithms have gained increasing relevance in AI-related inventions due to their distinct advantages.¹¹⁷ Firstly, evolutionary algorithms excel in the exploration of novel solutions, often identifying innovative approaches that may be missed by traditional methods or human designers.¹¹⁸ Additionally, they are effective in managing complex constraints, making them especially valuable for problems involving multiple, and sometimes conflicting, objectives. Their adaptability allows them to be applied to various problem types, ranging from

Novelty and Inventive Step: What Is the Impact of AI on Patent Law?’ in Z Sikorski and J Zemła-Pacud (eds), *Patents as an Incentive for Innovation* (Wolters Kluwer, Alphen aan den Rijn 2021) 256.

¹¹¹ Nayna Jaen, ‘Determining what AI data you need and how to source it’ (RWS, 8 April 2024) <https://www.rws.com/artificial-intelligence/train-ai-data-services/blog/determining-ai-data-needs-and-sourcing/>.

¹¹² The concept of Big Data arose in the late 1990s, culminating in the scholar Doug Laney, who formulated the theory of the three Vs in the early 2000s (later developed into four Vs), namely: variety (data has different forms, from pictures and videos, and to documents), volume (there is a large amount of data from different sources as social media and transactions), velocity (meaning the speed at which data flows in time) and the later added veracity (defined by the accuracy of data). For a summary of the concept see: Douglas Laney, ‘3D data Management: controlling data volume, velocity, and variety’ (Gartner, 2001) <http://blogs.gartner.com/douglaney/files/2012/01/ad949-3D-data-Management-Controlling-data-Volume-Velocity-and-Variety.pdf>; Agnieszka Smalec, ‘Big Data as a Tool Helpful in Communication Management’ (2021) 192 *Procedia Computer Science* 5157; Julius Černiauskas, ‘Understanding The 4 V’s Of Big Data’ (Forbes, 23 August 2022) <https://www.forbes.com/councils/forbestechcouncil/2022/08/23/understanding-the-4-vs-of-big-data/>.

¹¹³ On the use of big data in AI see: Ryan Abbott, ‘Hal the Inventor: Big Data and Its Use by Artificial Intelligence’ in Cassidy R Sugimoto, Hamid Ekbil and Michael Mattioli (eds), *Big data is not a monolith* (MIT Press 2016) 194.

¹¹⁴ For a more detailed discursus to big data see: Matthias Leistner, Lucie Antoine and Thomas Sagstetter, *Big Data – Rahmenbedingungen im europäischen Datenschutz- und Immaterialgüterrecht und übergreifende Reformperspektive* (Tübingen 2021), in particular 459 et seq.

¹¹⁵ The disclosure of AI training datasets raises further legal issues, such as with regard to their protection as trade secrets or *sui generis* rights, see on this see for example: Matthias Leistner, Lucie Antoine and Thomas Sagstetter, *Big Data – Rahmenbedingungen im europäischen Datenschutz- und Immaterialgüterrecht und übergreifende Reformperspektive* (Tübingen 2021).

¹¹⁶ Ibid.

¹¹⁷ Dipankar Dasgupta and Zbigniew Michalewicz, ‘Evolutionary Algorithms - An Overview’ in Dipankar Dasgupta and Zbigniew Michalewicz (eds), *Evolutionary Algorithms in Engineering Applications* (Berlin and Heidelberg 1997) 3 et seq.

¹¹⁸ Changhe Li et al., ‘Basics of Evolutionary Computation Algorithms’ in C Li, S Han, S Zeng and S Yang (eds), *Intelligent Optimization: Principles, Algorithms and Applications* (Springer Nature Singapore 2024) 63 et seq.

continuous optimization to combinatorial challenges.¹¹⁹ Moreover, their population-based structure makes them well-suited for parallel computing architectures, enhancing the efficiency of the search process.¹²⁰

The two most prominent examples of the use of evolutionary algorithms in research and development are the “Apparatus for Improved General-Purpose PID and non-PID controllers” by John Koza,¹²¹ in the field of genetic programming, and the NASA space antenna, developed in 2005, that flew on a miniature spacecraft as part of the Space Technology 5 mission.¹²² In the first example, genetic programming is said to be a form of evolutionary algorithms¹²³ that developed the said apparatus that was later patented.¹²⁴ In the second example, the design of new single arm antennas was less time and labour consuming by relying on evolutionary algorithms to come up with new structures.¹²⁵ The design of new single arm antennas was less time and labour consuming by relying on evolutionary algorithms to automatically design X-band antennas for their small satellites.¹²⁶ Up to this reasoning, the algorithm seems to be a tool helping humans in the inventive process. Still, the evolutionary algorithms were able to search a much wider design space and automatically find novel antenna designs that human engineers likely would not have conceived. According to a member of the team “no human engineer would have thought of an antenna that looked so crazy” and “yet the antenna works better than previous human designs”.¹²⁷ This last example will be further analysed in Section B.III.2.b.

d) Generative AI

Before the recent advances in general-purpose AI, the term ‘AI’ commonly referred to machine learning systems that generated predictions from input data. These models, typically trained on large-scale datasets, were employed in applications such as diagnosing tumours in radiographic images or evaluating the probability of loan default.¹²⁸ Such systems are particularly effective at identifying and internalising complex patterns and correlations within data, often beyond the

¹¹⁹ Ibid.

¹²⁰ Andrew N Sloss and Steven Gustafson, ‘Evolutionary Algorithms Review’ (2019) *arXiv* <https://doi.org/10.48550/arXiv.1906.08870>.

¹²¹ US Patent No 6,847,851 (issued 25 January 2005); see for *Kozas’* initial thoughts: John R Koza, *Genetic Programming: On the Programming of Computers by Means of Natural Selection* (MIT Press 1992); whereas more recently: John R Koza et al., *Genetic Programming IV: Routine Human-Competitive Machine Intelligence* (Kluwer Academic Publishers 2003).

¹²² Gregory Hornby et al., ‘Automated Antenna Design with Evolutionary Algorithms’ (2006) AIAA 2006-7242, Space 2006 <https://arc.aiaa.org/doi/10.2514/6.2006-7242>.

¹²³ Anne Eisenberg, ‘What’s Next: When a Gizmo Can Invent a Gizmo’ (New York Times, 25 November 1999) <https://www.nytimes.com/1999/11/25/technology/what-s-next-when-a-gizmo-can-invent-a-gizmo.html>; John Keats, ‘John Koza Has Built an Invention Machine’ (Popular Science, 1 May 2006) <https://www.popsoci.com/scitech/article/2006-04/john-koza-has-built-invention-machine/>.

¹²⁴ Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1088.

¹²⁵ Gregory Hornby et al., ‘Automated Antenna Design with Evolutionary Algorithms’ (2006) AIAA 2006-7242, Space 2006, 4-8 <https://arc.aiaa.org/doi/10.2514/6.2006-7242>.

¹²⁶ Ibid.

¹²⁷ Robert Plotkin, ‘Commentary: How AI is Affecting the Patent System’ (Reuters, 28 June 2023) <https://www.reuters.com/legal/litigation/how-ai-is-affecting-patent-system-2023-06-28/>.

¹²⁸ Adam Zewe, ‘Explained: Generative AI’ (MIT News, 9 November 2023) <https://news.mit.edu/2023/explained-generative-ai-1109>.

cognitive limits of human analysts.¹²⁹ By contrast, generative AI refers to models specifically trained to produce new data outputs, rather than forecast outcomes from existing datasets. These systems learn underlying patterns in their training data and are capable of generating new instances that resemble that original data.¹³⁰ Generative AI has gained prominence in creative domains, enabling the synthesis of text, images, music, and other forms of media that closely resemble human-created content.

Investment in generative AI is accelerating, with a Gartner report estimating the sector's value at over USD 1.7 billion and predicting significant impacts across healthcare, manufacturing, aerospace and other sectors. Potential applications include clinical education, drug discovery, and addressing knowledge deficits in under-resourced regions.¹³¹ The release of GPT-3 by OpenAI in 2020 was a pivotal moment, demonstrating the ability of LLMs to carry out a variety of natural language processing tasks.¹³² Subsequent innovations include DALL-E (2021), which generates images from textual prompts, and ChatGPT (2022), a conversational model that can produce a variety of text-based outputs.¹³³ Introduced in March 2023 and based on the GPT architecture, GPT-4 has expanded its capabilities to include creative domains such as writing, coding, and visual art generation.¹³⁴

Unlike search engines as Google or Bing, ChatGPT not only retrieves information but also generates coherent, human-like textual content.¹³⁵ However, while ChatGPT is capable of producing text that appears original, it does not possess inventiveness in a legal or cognitive sense. It lacks the ability to perceive or experience the world, make decisions, or engage in inventive thoughts. It can only generate text based on patterns in the data it was trained on, and its responses are limited to the information it has been exposed to.¹³⁶ "Distributed collective intelligence" would therefore be a better term to describe these methods since the output of generative AI can be explained by the input data, model creators' choices, and deployment conditions.¹³⁷

¹²⁹ Publications Office of the European Union, *The Role of Artificial Intelligence in Processing and Generating New Data* (11 July 2024) <https://data.europa.eu/en/publications/reports/role-artificial-intelligence-processing-and-generating-new-data>.

¹³⁰ Adam Zewe, 'Explained: Generative AI' (MIT News, 9 November 2023) <https://news.mit.edu/2023/explained-generative-ai-1109>.

¹³¹ European Parliamentary Research Service, *General-purpose AI: Understanding the technology and ensuring its responsible use* (Briefing, PE 745.708, March 2023), 1.

¹³² When asked how ChatGPT would describe itself, the answer is as a generative AI model, specifically, a language model that uses a type of deep learning algorithm called a transformer to generate text based on the input it receives. When a user asks it a question or gives it a prompt, it analyses the input, generates a response based on the context and its training data, and then provides that response to the user. This process allows it to generate human-like text that is coherent and relevant to the input provided (text generated by <https://chat.openai.com/> when asked "How would you describe ChatGPT? Are you a generative AI model?" on 21 March 2023).

¹³³ European Parliamentary Research Service, *General-purpose AI: Understanding the technology and ensuring its responsible use* (Briefing, PE 745.708, March 2023) 1.

¹³⁴ Daria Kim, 'On Words That Come Easy' (2023) *GRUR International* 1 et seq. <https://doi.org/10.1093/grurint/ikad030>; Melissa Heikkilä and Will Douglas Heaven, 'What's Next for AI' (MIT Technology Review, 23 December 2022) <https://www.technologyreview.com/2022/12/23/1065852/whats-next-for-ai/>.

¹³⁵ Ibid.

¹³⁶ OpenAI, *ChatGPT* <https://openai.com/blog/chatgpt/>.

¹³⁷ Daria Kim, 'On Words That Come Easy' (2023) *GRUR International* 1 et seq.

Particularly relevant for patent law are generative AI systems using deep learning to propose novel molecular structures that have not previously been synthesised or disclosed.¹³⁸ Yet, the question arises whether such generated outputs satisfy the criterion of an inventive step or merely constitute a recombination of known prior art. Moreover, generative AI offers practical assistance within the patent application process. For instance, in February 2023, US patent attorney Kirk Dorius used ChatGPT to draft a provisional patent application based on a single-sentence invention disclosure prompt (“Hey ChatGPT - write a patent on a roof top tent cover with traction board pockets along the side of the roof top tent cover”).¹³⁹ The resulting application was filed with the USPTO with only minor editorial modifications. The inventive concept was already complete at the stage of the prompt. ChatGPT’s role was limited to articulating and formatting the disclosure. This highlights the potential role of AI as a drafting assistant in patent prosecution, particularly for routine aspects of the process, thereby enhancing procedural efficiency.¹⁴⁰

e) Inventive AI

aa) Contextual Background

Although most scholars do not define inventive AI, some considerations are important for this work. Inventive AI can be considered a subtype of AI and refers to those AI systems that can come up with new and inventive ideas or solutions. This type of AI is useful in research and development, where it can help identify new scientific discoveries or technological innovations that humans might not have thought of.

Whilst generative AI is a broader term that focuses on creating new output that is similar to the training data, inventive AI might be seen as a more specific application focused on problem-solving and generating inventive ideas. Both involve creating something new, but inventive AI outputs would be the one that may qualify for patent protection, if the requirements are present. As AI technology evolves, the distinctions between these terms may blur, with generative AI increasingly being applied to inventive tasks.

bb) Assessing the Inventive Capabilities of AI

For the purposes of this work, it is essential to examine whether AI is, in fact, capable of engaging in inventive activity and producing an inventive contribution. If this capacity were categorically denied, AI would be regarded merely as an advanced tool.¹⁴¹

¹³⁸ Yugo Shimizu et al., ‘AI-driven Molecular Generation of Not-patented Pharmaceutical Compounds Using World Open Patent Data’ (2023) 15 *Journal of Cheminformatics* 120 <https://jcheminf.biomedcentral.com/articles/10.1186/s13321-023-00791-z#citeas>.

¹³⁹ Kirk Dorius, ‘AI Wrote My Patent Application in 30 Seconds and It Is Now Pending with the USPTO’ (2023) <https://www.linkedin.com/pulse/ai-wrote-my-patent-application-30-seconds-now-pending-kirk-dorius>.

¹⁴⁰ Ibid.

¹⁴¹ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 126.

Some scholars reject the notion that AI can engage in inventive activity.¹⁴² They argue that AI is limited to the data it has been provided and cannot consider contextual or external variables and, consequently, the act of creation must be executed by a human.¹⁴³ According to this view, AI would be incapable of taking inventive approaches as inventive capacity is reserved for beings “with intellect and imagination”, meaning that only the human mind is capable of genuine creativity and, hence, invention.¹⁴⁴ This view, however, is not persuasive. In practice, trained AI systems can indeed produce new insights.¹⁴⁵ This is illustrated, for example, by *Thaler’s* “Creativity Machine” or NASA’s space antenna design (later discussed in Section B.III.2.b). These examples demonstrate that AI is capable of pursuing novel approaches, even in contexts where such capacity might not be anticipated.¹⁴⁶ They show that what is recognized as “inventive” does not necessarily require a mental act in the traditional sense.¹⁴⁷

Moreover, from a patent law perspective, it is immaterial whether the human inventor consciously created the invention or understands its underlying mechanisms. What matters is the ability to describe a method by which the technical result is achieved.¹⁴⁸

Furthermore, the argument that AI lacks inventive capability because it depends on pre-existing data is not entirely convincing, as humans also rely on accumulated knowledge and experiences acquired throughout life.¹⁴⁹ In this sense, the scope of information from which humans derive new insights is equally limited. The way AI arrives at new findings closely resembles intellectual and creative processes.¹⁵⁰ In contrast to traditional computer programs, where the solution is explicitly coded by the developer via finite, algorithmic instructions, trained AI systems can autonomously identify patterns, correlations, and rules within datasets.¹⁵¹ These abilities emulate intellectual and creative reasoning, allowing AI to produce inventive outcomes based on acquired knowledge. In doing so, AI contributes meaningfully to the inventive process.¹⁵²

¹⁴² See for example: Benjamin Williams, ‘The European Solution for Text and Data Mining: A Focus on the Opt-Out System Provided by Article 4 of the DSM Directive’ (2021) 43(12) *EIPR* 790; Lea Tochtermann, ‘Immaterialgüterrechtlicher Schutz von KI *de lege ferenda*’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Munich 2020) 327 et seq.

¹⁴³ Tim W Dornis, ‘Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 1)’ (2020) *Mitteilungen der deutschen Patentanwälte* 439; Bernhard Volmer, ‘Die Computererfindung: Unter besonderer Berücksichtigung des Arbeitnehmererfinderrechts’ (1971) *Mitteilungen der deutschen Patentanwälte* 257.

¹⁴⁴ Bernhard Volmer, ‘Die Computererfindung: Unter besonderer Berücksichtigung des Arbeitnehmererfinderrechts’ (1971) *Mitteilungen der deutschen Patentanwälte* 257.

¹⁴⁵ Tim W Dornis, ‘Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 1)’ (2020) *Mitteilungen der deutschen Patentanwälte* 439.

¹⁴⁶ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 127.

¹⁴⁷ *Ibid.*, 129.

¹⁴⁸ Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 64.

¹⁴⁹ Erich Zipse, ‘Computer oder nachvollziehender Mensch als Erfinder?’ (1972) *Mitteilungen der deutschen Patentanwälte* 42.

¹⁵⁰ Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 70.

¹⁵¹ Sven J Körner, ‘Nachvollziehbarkeit von KI-basierten Entscheidungen’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Munich 2020) 44 et seq.

¹⁵² Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 129 et seq.

It is acknowledged that, under current technological constraints, AI lacks intentionality and an understanding of the significance of invention.¹⁵³ However, these limitations, or the concurrent creative input of a human, do not negate the AI's actual contribution to the inventive process. Importantly, the present inquiry does not concern whether AI can be *solely* inventive but whether it can contribute inventively *at all*.¹⁵⁴ This perspective is reinforced by adopting a functional understanding of the term “intellectual-creative”: a contribution should be deemed such if it would qualify as intellectual and creative had it been made by a human.¹⁵⁵

To further clarify, the following thought experiment, provided by *Schrön* and grounded in the current state of technology, can be considered.¹⁵⁶ Suppose a creative contribution to an invention is not made *by or with* an AI, but by a human. Two fictional individuals, M and C, represent the human and computer components, respectively. If M provides C with a complete, step-by-step solution (like to traditional programming), then C acts solely under M's instruction and does not contribute creatively.¹⁵⁷ M alone would be considered the inventor. However, if M trains C and provides only general procedural guidance, without specifying every individual step, C would need to independently identify patterns and relationships within the dataset, thereby contributing to the solution. If C's contribution is non-trivial, both M and C would be co-inventors and entitled to joint patent rights.¹⁵⁸ Disregarding the fact that if C were an AI system, only M would be named, as current patent law recognizes only natural persons as inventors, AI systems, according to current technological standards, are already capable of making factual inventive contributions.

2. The Three Levels of AI

AI can be categorised in three types:¹⁵⁹

- artificial narrow intelligence, also known as limited or weak AI,
- artificial general intelligence also known as strong AI, and
- artificial super intelligence.

¹⁵³ Compare Tim W Dornis, ‘Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 1)’ (2020) *Mitteilungen der deutschen Patentanwälte* 438.

¹⁵⁴ Lea Tochtermann, ‘Immaterialgüterrechtlicher Schutz von KI *de lege ferenda*’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Munich 2020) 327 et seq. (in particular § 40).

¹⁵⁵ Ibid; compare also Peter Blok, ‘The inventor's new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 69.

¹⁵⁶ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 130-131.

¹⁵⁷ Bernhard Volmer, ‘Die Computererfindung: Unter besonderer Berücksichtigung des Arbeitnehmererfinderrechts’ (1971) *Mitteilungen der deutschen Patentanwälte* 256.

¹⁵⁸ Compare also Lea Tochtermann, ‘Immaterialgüterrechtlicher Schutz von KI *de lege ferenda*’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Munich 2020) 327 et seq. (in particular § 40).

¹⁵⁹ Alexander Donovan, ‘Tech Leaders Have Strong Opinions on Artificial Intelligence’ (Interesting Engineering, 1 April 2020) <https://interestingengineering.com/innovation/tech-leaders-have-strong-opinions-on-artificial-intelligence>.

a) Artificial Narrow Intelligence

According to most researchers, the current stage of AI is characterised as artificial narrow intelligence, which refers to AI systems that are designed to perform a specific task or set of limited tasks.¹⁶⁰ These systems leverage substantial computational power and extensive datasets to automate repetitive tasks efficiently, without being able to repurposed for other tasks.¹⁶¹ In order to tackle a new problem, the programmer has to start from scratch. Despite their advanced capabilities and being able to simulate some basic cognitive functions, such systems lack the general cognitive abilities inherent to humans and lack human-like intelligence.¹⁶²

Human involvement is currently necessary in various stages of the AI life cycle. In the first stage, an engineer must mathematically describe a problem and build a model by adapting a general algorithm to the specific model and selecting relevant datasets. In the second stage, the algorithm must be trained, which may also require human involvement.¹⁶³ For example, in supervised learning, the algorithm must receive feedback on its training runs to improve its performance. This feedback often takes the form of human-annotated data, enabling the algorithm to verify its outputs and adjust its inner workings, such as coefficients and thresholds.¹⁶⁴

Contemporary AI underpins numerous widely used technologies, including ChatGPT, Google Translate, Siri, Cortana, and Alexa. While ChatGPT demonstrates impressive proficiency in natural language processing, it remains a form of narrow AI, as it operates primarily within language- and modality-constrained tasks. As of mid-2025, even with the advent of multimodal systems such as GPT-4o, it lacks the ability to autonomously generalize knowledge across fundamentally different domains in a manner characteristic of artificial general intelligence. ChatGPT describes itself as a “narrow or specialized AI”, capable of performing “a wide range of language-related tasks, such as drafting text, summarising information, generating code, and answering questions, with impressive fluency”, while also acknowledging that it does not possess “autonomous reasoning, self-awareness, intentionality, or a true understanding of the world”.¹⁶⁵

¹⁶⁰ Anirudh V K, ‘The 3 Types of Artificial Intelligence Explained’ (Spiceworks, 10 February 2022) <https://www.spiceworks.com/tech/artificial-intelligence/articles/types-of-ai/>.

¹⁶¹ Jason D Lohr, ‘Managing Patent Rights in the Age of Artificial Intelligence’ (Legaltech News, 18 August 2016) <https://www.law.com/legaltechnews/almID/1202765385194/Managing-Patent-Rights-in-the-Age-of->.

¹⁶² Ibid.

¹⁶³ In 2019, the OECD outlined the AI system lifecycle in their Recommendation of the Council on AI. This lifecycle includes context-specific phases that are not always sequential and may involve iterative steps. The four primary phases are: (a) design, data, and models, which encompasses planning and design, data collection and processing, and model development; (b) verification and validation; (c) deployment; and (d) operation and monitoring (OECD, ‘Recommendation of the Council on Artificial Intelligence’ (2019) <https://legalinstruments.oecd.org/api/print?id=648&lang=en>, 7; OECD, *Artificial Intelligence in Society* (2019) 25, <https://www.oecd.org/publications/artificial-intelligence-in-society-eedfee77-en.htm>).

¹⁶⁴ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq. <https://www.jipitec.eu/archive/issues/jipitec-13-2-2022/5537>.

¹⁶⁵ Answer provided by ChatGPT on 2 August 2025, when asked “Are you a general purpose AI?”.

Similarly, applications like spam filters and software for handwritten digit recognition exemplify narrow AI, excelling in their designated functions but devoid of broader reasoning or learning capabilities beyond their specific programming.¹⁶⁶

b) Artificial General Intelligence

The next level would be artificial general intelligence, which is understood as a developmental stage in which a machine possesses the capacity to understand, learn, and perform a wide range of tasks at a human-comparable level. Such a system would be capable of generalising knowledge across domains, and potentially surpass human abilities in certain areas, while remaining deficient in others.¹⁶⁷ Some researchers posit that artificial general intelligence would be ‘self-aware’, capable of developing its own intelligence independently rather than by mimicking human cognitive processes.¹⁶⁸ Research in this domain is largely inspired by the human brain’s architecture, employing artificial neural networks engineered for tasks such as pattern recognition and audio-visual classification.¹⁶⁹

Although artificial general intelligence was historically regarded as a distant or even unattainable objective, recent progress in LLMs has rendered the prospect more feasible.¹⁷⁰ These advances have led to the emergence of foundation models, large-scale, general purpose AI systems trained on extensive unlabelled datasets.¹⁷¹ These models are capable of performing multiple tasks with minimal fine-tuning and are increasingly accessible through application programming interfaces and open-source frameworks, enabling developers to build derivative tools and services across various sectors.¹⁷²

Still, as *Gigerenzer* explains, AI’s potential is based on the “illusion of certainty”.¹⁷³ This idea highlights the tendency to overestimate AI’s capabilities based on specific achievements.¹⁷⁴ This illusion is often based on two premises: “AI has beaten the best players in chess and Go” and “Computing power doubles approximately every two years” (often referred to as *Moore’s*

¹⁶⁶ Eban Escott, ‘The 3 Types of AI: Is the Third Even Possible?’ (Codebots, 24 October 2017) <https://codebots.com/artificial-intelligence/the-3-types-of-ai-is-the-third-even-possible>; IBM Data and AI Team, ‘Types of Artificial Intelligence | IBM’ (IBM, 12 October 2023) <https://www.ibm.com/think/topics/artificial-intelligence-types>.

¹⁶⁷ Linda S Gottfredson, ‘Mainstream Science on Intelligence: An Editorial With 52 Signatories, History and Bibliography’ 24(1) *Intelligence* 13 et seq.

¹⁶⁸ Jerry Cole, ‘AI and the Question of Consciousness: Can Machines Engage in Self-Inquiry?’ (2025) *ResearchGate* 1 et seq., https://www.researchgate.net/publication/391007117_AI_and_the_Question_of_Consciousness_Can_Machines_Engage_in_Self-Inquiry.

¹⁶⁹ Ibid.

¹⁷⁰ European Parliamentary Research Service, *General-purpose AI: Understanding the technology and ensuring its responsible use* (Briefing, PE 745.708, March 2023), 1 [https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/745708/EPRS_ATA\(2023\)745708_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/745708/EPRS_ATA(2023)745708_EN.pdf).

¹⁷¹ Ibid.

¹⁷² Ibid.

¹⁷³ Gerd Gigerenzer ‘Certainty as an Illusion: We Should Learn to Live Without It’ (Philonomist, 29 May 2024) <https://www.philonomist.com/en/entretien/certainty-illusion-we-should-learn-live-without>.

¹⁷⁴ Felicia Moraru and Nick Cretu ‘Interview with Gerd Gigerenzer on the Future of AI’ (Founders Project, 26 January 2024) <https://www.foundersproject.io/p/gerd-gigerenzer-ai>.

Law).¹⁷⁵ While these premises are generally correct, they can lead to an erroneous conclusion that “machines will soon be able to do everything better than humans”.¹⁷⁶ This conclusion oversimplifies the complex nature of intelligence and the current state of AI technology. While AI has indeed achieved remarkable feats in specific domains like chess and Go, and computing power continues to increase, though not always strictly adhering to *Moore’s Law*, these achievements do not necessarily translate to a general ability to outperform humans across all tasks and domains.¹⁷⁷

Although some experts estimate a 25% probability of artificial general intelligence being achieved around 2035, such projections remain speculative and should be approached cautiously.¹⁷⁸ Historically, predictive claims about AI’s capabilities have frequently proven unreliable. Achieving artificial general intelligence would necessitate fundamental breakthroughs in both the theoretical and practical foundations of AI.¹⁷⁹

c) Artificial Super Intelligence

Artificial super intelligence is a hypothetical form of AI which is expected to surpass human intelligence. According to *Bostrom*, a superintelligence refers to “any intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest”.¹⁸⁰ This concept represents a significant leap beyond current AI capabilities and even beyond the yet-to-be-achieved artificial general intelligence. *Bostrom’s* definition of superintelligence encompasses a broad range of capabilities, including scientific creativity, wisdom, and social skills. This implies that an artificial super intelligence would not only be able to process

¹⁷⁵ Moore’s Law is only used as an example in this context and “two” can be changed to “X” for the purpose of this discussion. As of 2024, Moore’s Law remains relevant but with important modifications. The original idea of doubling transistor density every two years no longer strictly applies, as the pace of improvement has slowed due to physical and economic limitations in chip manufacturing. Despite these challenges, the semiconductor industry continues to innovate through new materials, 3D chip stacking, and alternative computing methods. The focus has also expanded to include broader metrics of computing performance and efficiency. Although the doubling rate has shifted, the core trend of rapid advancement in computing power still fuels technological progress. (Nick Bostrom, ‘How Long Before Superintelligence?’ (1998) 2 *International Journal of Future Studies* <https://nickbostrom.com>; Carla Tardi, ‘What Is Moore’s Law and Is It Still True?’ (Investopedia, 2 April 2024) <https://www.investopedia.com/terms/m/mooreslaw.asp>; Nick Zhang, ‘Moore’s Law is Dead, Long Live Moore’s Law!’ (ResearchGate, 2022) https://www.researchgate.net/publication/360962195_Moore%27s_Law_is_dead_long_live_Moore%27s_Law).

¹⁷⁶ Gerd Gigerenzer, *How to Stay Smart in a Smart World: Why Human Intelligence Still Beats Algorithms* (The MIT Press 2022) 45 et seq., Daniele Manca e Gianmario Verona ‘Intelligenza, non solo artificiale: il potenziale di una tecnologia di cui non siamo ancora davvero consapevoli’ (Corriere della Sera, 28 November 2022).

¹⁷⁷ Gary Marcus and Ernest Davis, *Rebooting AI: Building Artificial Intelligence We Can Trust* (Pantheon 2019) 30 et seq.

¹⁷⁸ Cem Dilmegani and Sila Ermut, ‘When Will AGI/Singularity Happen? 8,590 Predictions Analyzed’ (AI Multiple, 1 August 2025).

¹⁷⁹ Archil Cheishvili, ‘The Future of Artificial General Intelligence’ (Forbes, 16 July 2021) <https://www.forbes.com/sites/forbestechcouncil/2021/07/16/the-future-of-artificial-general-intelligence/?sh=672b07783ba9>.

¹⁸⁰ Sebastian Benthall, ‘Bostrom’s Superintelligence: Definitions and Core Argument’ (Digifesto, 20 August 2015) <https://digifesto.com/2015/08/20/bostroms-superintelligence-definitions-and-core-argument/>; see also: Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (OUP 2014).

information faster than humans but would also possess superior problem-solving abilities, creativity, and even emotional intelligence.¹⁸¹

In 1965, in his article “Speculations Concerning the First Ultraintelligent Machine”, *Good* reasoned that an ultra-intelligent machine could surpass human intelligence in all intellectual activities, including creating better machines.¹⁸² Since machine design and creation are intellectual activities, an ultra-intelligent machine could create better machines, that could surpass human intellect.¹⁸³ In fact, the first ultra-intelligent machine will be the last invention that humans will need to invent, but reality is still far from it.¹⁸⁴

The path from current narrow AI systems to artificial general intelligence, and then to artificial super intelligence, involves numerous technological and conceptual challenges that are not yet fully understood. Technological progress will lead to a future in which the pace of change will be so radical that human life will be irreversibly transformed.¹⁸⁵ However, the exact timeline is once again highly speculative.

3. Preliminary Results

AI encompasses several subfields, many of which contribute to AI-related inventions. Machine learning, for instance, allows software to learn from experience, identifying patterns and adapting to data without the need for explicit programming. Machine learning is distinct from deep learning, which automates much of the data analysis process by eliminating the need for manual feature extraction. The key difference lies in the learning modes: deep learning automates processes, while machine learning depends on human intervention for feature selection. Artificial neural networks, a subset of machine learning, are critical in deep learning algorithms and mimic the structure of the human brain. They are composed of layers of nodes that communicate with one another, each with an assigned weight and threshold. During the training process, the structure of these networks is altered to match a specific task, which allows them to learn from and adapt to data. Artificial neural networks have been applied to various fields, such as game-playing AI like AlphaZero and the creation of innovative designs like the cross-bristle toothbrush by *Thaler’s* “Creativity Machine”. Evolutionary algorithms, another important AI subtype, mimic natural selection by generating solutions to problems through mutations or crossovers. These algorithms are particularly useful in tackling complex optimization problems and have been applied in inventions like NASA’s space antenna design

¹⁸¹ Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (OUP 2014).

¹⁸² Irving J Good, ‘Speculations Concerning the First Ultraintelligent Machine’ in F Alt and M Ruminoff (eds), *Advances in Computers* (vol 6, Academic Press 1965) 31 et seq.

¹⁸³ Ibid.

¹⁸⁴ On the concept of “last invention” see James Barrat, *Our Final Invention: Artificial Intelligence and the End of the Human Era* (Thomas Dunne Books 2013); see also: on the importance of the work on AI, Lauren Goode, ‘Google CEO Sundar Pichai compares impact of AI to electricity and fire’ (The Verge, 19 January 2018) <https://www.theverge.com/2018/1/19/16911354/google-ceo-sundar-pichai-ai-artificial-intelligence-fire-electricity-jobs-cancer>.

¹⁸⁵ Andrea D Signorelli, ‘I tre livelli dell’intelligenza artificiale’ (5 November 2019) <https://andreadanielesignorelli.com/2019/11/05/tre-livelli-intelligenza-artificiale-ani-agi/>.

and *Koza's* genetic programming innovations.¹⁸⁶ Evolutionary algorithms stand out for their ability to explore novel solutions without relying on extensive data. Generative AI, exemplified by models like ChatGPT, represents the current frontier of AI technology. These systems generate new content based on patterns in input data, creating realistic images, videos, music, or text. While generative AI shows promise in creative fields, it lacks the ability to invent or conceive new ideas independently. It can only generate outputs based on the data it has been trained on, a limitation that raises questions about its role in patent law, particularly regarding whether its outputs involve inventive steps or merely combine prior art. Inventive AI, while not a formally defined term, refers to AI systems capable of generating new and inventive ideas or solutions. Unlike generative AI, which primarily replicates existing data, inventive AI is applied to tasks like research and development, where it helps identify novel discoveries or technological innovations. This type of AI could qualify for patent protection if the required inventive steps are present.

AI is often classified into three levels: artificial narrow intelligence, artificial general intelligence, and artificial super intelligence. Currently, most AI systems are examples of artificial narrow intelligence, capable of performing specific, narrow tasks like language translation or facial recognition. Artificial general intelligence, which remains theoretical, would be capable of performing any intellectual task a human can do, while artificial super intelligence, also hypothetical, would surpass human intelligence in all domains.

In summary, the conceptual development of AI has seen a series of significant milestones, from the creation of the first artificial neuron to the development of modern machine learning technologies. The field continues to face both technical and legal challenges, particularly as AI systems become more advanced. As AI technology continues to evolve, the distinctions between generative and inventive AI may become blurred, with AI increasingly contributing to inventive processes across various fields.

III. Categorization of AI-Outputs

1. Classifications of “AI-Inventions”

For patent law, it is useful to define the concept of an “AI-invention”. Typically, this term encompasses two distinct groups. First, inventions that have AI as part of their mechanism (Category I-III),¹⁸⁷ and second, the focus of this work, inventions that are designed, assisted, or

¹⁸⁶ For examples of the use of AI tools in the aircraft design and certification see: Adam Gavine, ‘AI Tool Set Underway for Aircraft Design and Certification’ (Aircraft Interiors International, 21 May 2020) <https://www.aircraftinteriorsinternational.com/news/mro/ai-tool-set-underway-for-aircraft-design-and-certification.html>.

¹⁸⁷ For the purposes of this work, the following inventions will be referred to as “AI-implemented inventions”, where AI is implemented as (part of) the invention. (see also: Josef Drexl et al., ‘Comments of the MPI of 11 February 2020 on the Draft Issues Paper of the WIPO on Intellectual Property Policy and Artificial Intelligence’ (2020) https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/2020-02-11_WIPO_AI_Draft_Issue_Paper_Comments_Max_Planck.pdf); the WIPO eventually adopted the terminology proposed by the MPI: see WIPO, ‘AI inventions’ (2023) https://www.wipo.int/export/sites/www/about-ip/en/frontier_technologies/pdf/WIPO_AI_Inventions_factsheet.pdf).

made by AI (Category IV-V; together summarised under the term “AI-related” inventions), but do not necessarily have AI in their inventive mechanism (for example, a medical compound discovered with the assistance of AI).¹⁸⁸

AI as the subject-matter of an invention (Category I-III) or as a tool to invent or the inventor (Category IV-V), are distinct aspects.¹⁸⁹ Still, Category IV-V do not per se preclude the invention from being also AI-implemented, meaning that an AI would invent another AI.¹⁹⁰ Generally speaking, the material inventor can be described as the individual or entity that has generated a particular invention, therefore the one that has created a technical teaching that fulfils the above-defined concept of an invention, intended for technical application. This perspective aligns with the stance taken by Germany’s Federal Court of Justice’s (BGH) “*Schleppfahrzeug*” decision.¹⁹¹ The Court has clarified that an inventor is, unequivocally, the person who has actively developed the technical teaching in question.¹⁹² As AI systems become more autonomous in generating inventions, it becomes less clear whether the human operator can be considered to have “actively developed” the technical teaching, as required by the Germany’s Federal Court of Justice’s definition. Thus, within the domain of patent law, the importance of the inventor principle has significantly waned due to advancements in AI.¹⁹³ In numerous fields, the inventor has evolved into a symbolic figure lacking substantial significance.¹⁹⁴ As a result, when evaluating AI-related inventions, relying solely on the inventor principle is inadequate.¹⁹⁵ Although the role of individuals in the invention process and reception is decreasing in significance, the inventions generated by or with the help of AI remain of significant importance.¹⁹⁶

¹⁸⁸ Christian Heinze and Andreas Engel, ‘KI und Patentrecht’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 57 et seq.

¹⁸⁹ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 18.

¹⁹⁰ *Ibid.*, 17.

¹⁹¹ BGH, Judgment of 15 May 2001, X ZR 227/99 - *Schleppfahrzeug* [2001] GRUR 823, § 12.

¹⁹² *Ibid.*

¹⁹³ See Ryan Abbott and Elizabeth Rothman, ‘AI-Generated Output and Intellectual Property Rights: Takeaways from the Artificial Inventor Project’ (January 2023) 45(4) *European Intellectual Property Review* 215 et seq.

¹⁹⁴ Analogue applicable Adolf Dietz, ‘Das Urhebervertragsrecht in seiner rechtspolitischen Bedeutung’ in F K Beier (ed), *Urhebervertragsrecht. Festgabe für Gerhard Schricker zum 60. Geburtstag* (Munich 1995) 1, 22; Matthias Leistner and Gerd Hansen, ‘Die Begründung des Urheberrechts im digitalen Zeitalter. Versuch einer Zusammenführung von individualistischen und utilitaristischen Rechtfertigungsbemühungen’ (2008) *GRUR* 479.

¹⁹⁵ Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 22.

¹⁹⁶ For more on the implications on the inventor principle of inventions without an inventor see: Thomas H Meitinger, ‘Erfinderlose Erfindungen durch Know-how einer Organisation und Erfinderprinzip: kein Widerspruch’ (2017) *Mitteilungen der deutschen Patentanwälte* 149 et seq.; Benjamin Pesch and Kather Augenstein, ‘Unzureichende Erfinderbenennung bei Angabe künstlicher Intelligenz’ (2020) *GRUR-Prax* 84 et seq.

The identified categories are elucidated as follows:¹⁹⁷

Category	Type	Principal issues	Description
Category I	Invention of an AI	Potential patent eligibility issues	Category I concerns the creation of novel algorithms or models for AI itself, without regard to the data it processes or any specific application. This ‘core AI’ includes innovations such as new types of deep neural networks that surpass previous ones in performance. In this category, inventions are primarily oriented towards refining AI technologies. They are products of human ingenuity directed at enhancing the capabilities of existing AI frameworks. ¹⁹⁸
Category II	Invention of an AI implementation	Potential patent eligibility issues	Category II involves designing a system or process that broadly applies known AI technologies combined with additional elements, such as a specific configuration of filters or a unique interface. ¹⁹⁹
Category III	A new application of AI	Potential patent eligibility issues	Category III are the most frequently patented AI-inventions, for example artificial neural networks. These applications can be categorized into two main types: ‘decision maker’ and ‘decision aid’. In ‘decision maker’ applications, AI initiates actions, such as stopping a car, displaying product recommendations on a website, or opening a door upon facial recognition. In ‘decision aid’ applications, AI conducts analyses that provide valuable information for decision-makers without making decisions itself. ²⁰⁰

¹⁹⁷ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era (with a focus on inventive step)’ (WIPO Conversation on IP and Frontier Technologies, Sixth Session, Panel 3, 21 September 2022); Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 5-6.

¹⁹⁸ Ibid.

¹⁹⁹ Ibid.

²⁰⁰ Ibid.

Category IV	Invention created by using AI as a tool	Disclosure requirements and inventive step	In category IV, AI is employed by a human inventor to tackle a specific problem or need. This process involves identifying the problem, selecting the appropriate AI technology, and choosing suitable training and input data, resulting in a potentially patentable invention. Typically, these inventions solve the identified problem. However, sometimes the invention addresses a different problem than initially intended, suggesting the invention was made ‘accidentally’ using AI. ²⁰¹
Category V	Inventions predominantly or autonomously made by AI	Disclosure requirement, inventive step, and inventorship	In this category, innovations are autonomously generated by AI systems. While human intervention may be required in initiating the inventive process (for example “generate something like ...”), the AI takes a more autonomous role in actualizing the invention. ²⁰² The delineation of Category IV-V is based on the role of AI and the level of human involvement.

For the purpose of a brief overview, core AI inventions (Category I) often involve new machine learning algorithms or computational models, such as new neural network architectures. If such an invention clears the first hurdle, meaning computer implementation, the next question is whether it non-obviously advances prior art.²⁰³ If the novelty lies solely in the algorithm or model, it must serve a technical purpose. As noted in decision T 1784/06, an intrinsically non-technical solution (like a mathematical algorithm) must solve a technical problem to be considered technical.²⁰⁴ Without this, the algorithm does not qualify for the inventive step examination. It must be assessed if the computational model or algorithm indirectly contributes to the technical character. Claims not restricted to a specific technical application are unlikely to be considered inventive. Conversely, claims requiring a specific technical implementation may be viewed as new AI implementations (Category II).²⁰⁵ Claims for inventions that neither

²⁰¹ Ibid.

²⁰² Ibid.

²⁰³ For more on the regulation of computer-implemented inventions, see for example: Matthias Leistner, ‘Computerimplementierte Erfindungen im System des Geistigen Eigentums’ in O Peifer and K Depenheuer (eds), *Geistiges Eigentum: Schutzrecht oder Ausbeutungstitel? Zustand und Entwicklungen im Zeitalter von Digitalisierung und Globalisierung* (Berlin and Heidelberg 2008) 187 et seq.

²⁰⁴ EPO, T 1784/06, 21 September 2012 (*Classification method/COMPTEL*), § 10.1 and 11.5.

²⁰⁵ Jochen Ehlers et al., ‘European Patent Office’, in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 106-107.

serve a specific technical purpose nor require a specific technical implementation are likely to be rejected for lacking an inventive step under Article 56 EPC.²⁰⁶ Computational efficiency arguments often fail unless the mathematical method contributes to a technical effect.²⁰⁷

New AI implementations (Category II) typically involve more technical elements and interactions, which favour the inventive step assessment. The underlying method must adapt to specific technical implementations.²⁰⁸ If this adaptation is non-obvious in view of prior art, it may contribute to an inventive step under Article 56 EPC. For instance, implementing machine learning steps on specific hardware like graphic processing units and central process units can be inventive if it involves non-obvious technical interactions. If a mathematical method does not contribute to the technical character, the inventive step focuses solely on the algorithm's technical implementation, which is usually not considered inventive.²⁰⁹

Claims directed to new applications of known AI technology (Category III) may be novel if a known machine learning feature is used in a new application or if the application itself is novel. If the application has technical character and limits the claim, it may contribute to the inventive step. However, applying known AI to known applications is often seen as a common choice. When the novelty lies in using a machine learning model, it often fails the inventive step analysis, as seen in decision T 1191/19.²¹⁰ Demonstrating technical advantages of the machine learning model is challenging, especially without detailed disclosure of the training process, as noted in T 161/18.²¹¹ The inventive step is harder to defend if the machine learning model's superiority over previous mathematical functions is not demonstrated, as in T 2803/18.²¹² Part G-VII, 5.4.2.5 of the EPO Guidelines, drawing from decision T 1968/08, highlights the need for concrete technical effects beyond different adjustments of process parameters.²¹³ Obtaining a patent for Category III inventions requires tying machine learning features with inherently technical features. The tension between the inventive step and sufficiency of disclosure means the description must robustly support the technical effect of the claimed solution.²¹⁴ For inventions where AI application results in a patentable invention with technical character, the inventive step will likely be assessed using the problem-and-solution approach, regardless of the AI tool used.

Still, the focus of this work are Category IV-V inventions, that are together summarized as “AI-related” inventions for the scope of this thesis.

²⁰⁶ EPO Guidelines 2025, Part G-II, 3.3 and 3.6; see also: Philip Cupitt, ‘EPO Updates Guidelines for Examining AI Inventions’ (The Patent Lawyer Magazine, 20 February 2024) <https://patentlawyermagazine.com/epo-updates-guidelines-for-examining-ai-inventions/>.

²⁰⁷ EPO Guidelines 2025, Part G-II, 3.3; see also: EPO, T 1358/09, 21 November 20214 (*Classification/BDGB ENTERPRISE SOFTWARE*); EPO, G 1/19, 10 March 2021 (*Pedestrian simulation*).

²⁰⁸ Philip Cupitt, ‘EPO Updates Guidelines for Examining AI Inventions’ (20 February 2024, The Patent Lawyer Magazine) <https://patentlawyermagazine.com/epo-updates-guidelines-for-examining-ai-inventions/>.

²⁰⁹ EPO, T 1358/09, 21 November 20214 (*Classification/BDGB ENTERPRISE SOFTWARE*), § 5.7.

²¹⁰ EPO, T 1191/19, 1 April 2022 (*Neuronal plasticity/INSTITUTGUTTMANN*).

²¹¹ EPO, T 161/18, 12 Mai 2020 (*Äquivalenter Aortendruck/ARC SEIBERSDORF*).

²¹² EPO, T 2803/18, 13 December 2022.

²¹³ EPO Guidelines 2025, Part G-VII, 5.4.2.5; EPO, T 1968/08, 10 August 2010.

²¹⁴ Jochen Ehlers et al., ‘European Patent Office’, in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 108.

2. Types of AI-Related Inventions

The boundary between AI-assisted and AI-generated inventions cannot be clearly drawn, and no uniform understanding exists regarding the precise scope of either category. This uncertainty is intensified by the absence of a clear definition of “autonomy”, and, consequently, no universally accepted threshold exists for determining when a system may be considered independent of human control and capable of operating autonomously.²¹⁵ Therefore, rather than relying on a contested notion of autonomy, this work adopts the grade of human inventive contribution as the decisive criterion for classification. Consequently, debates about whether an AI can act autonomously, or whether such autonomy entails self-determination or self-governance, become redundant.²¹⁶

AI output can, at least from a theoretical standpoint, be divided into two main categories based on the degree of influence of computer systems in the creation of works and inventions: AI-assisted (Category IV) and AI-(autonomously) generated inventions (Category V).²¹⁷ This classification should at least in theory account for whether an inventive process originates from a human being or (equally, predominantly or completely) from an AI and allows for an assessment under patent law.²¹⁸

a) AI-Assisted Inventions

Category IV refers to an invention generated with the help of AI, where the inventive activity is carried out by a human and the human creative input predominates.²¹⁹ This category includes inventions where a human defines the underlying technical problem and utilises AI as a tool in the inventive process.

A noteworthy debate in patent law surrounds the characterization of AI systems, with some contending that they function merely as tools employed by individuals to generate inventions, similar to conventional instruments like a pencil or a microscope.²²⁰ The determination of whether highly advanced AI is simply a tool or more, fundamentally depends on how a “tool”

²¹⁵ Martin Ebers, ‘Regulierung von KI und Robotik’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) 89 et seq.; Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 446 et seq.; Daria Kim et al., ‘Clarifying Assumptions About Artificial Intelligence Before Revolutionising Patent Law’ (2022) *GRUR International* 306 et seq.

²¹⁶ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 189.

²¹⁷ Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 5-6; Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era (with a focus on inventive step)’ (WIPO Conversation on IP and Frontier Technologies, Sixth Session, Panel 3, 21 September 2022).

²¹⁸ Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 446 et seq.

²¹⁹ Ana P Gonzalez Torres, ‘AI-generated inventions: (A)I, inventor?’ (IusItinere, 27 April 2022) https://www.iusinitinere.it/ai-generated-inventions-ai-inventor-42263#_ftn9.

²²⁰ See for example: Corey Salsberg, ‘Novartis Comments on Artificial Intelligence and Inventorship (Docket PTO–P–2022–0045, 88 FR 9492)’ (Novartis, 15 May 2023).

is defined.²²¹ Hauser defines a tool as “an object that has been modified to fit a purpose ... [or] An inanimate object that one uses or modifies in some way to cause a change in the environment, thereby facilitating one’s achievement of a target goal”.²²² One shared characteristic of all tools is their reliance on human direction.

Humankind has used all sorts of different tools for hundreds of millennia, some found in nature, other self-built starting with materials such as stone, bone, and wood. Historically tools were built and used for different activities, including research. Thanks to the development of metalworking, the industrial revolution and later the advent of technology, tools became more sophisticated and increasingly complex. With the increased automation in the 19th and 20th centuries, tools started to operate with less human input and supervision, leading the path to the technologies that are used in the 21st century, AI being amongst them.

For years, engineers and designers have used AI methods like artificial neural networks and evolutionary algorithms to solve optimisation issues. Today their application in research and development relies primarily on the judgement of human designers and engineers who employ these techniques to solve specific problems.²²³ This involvement includes tasks like problem analysis and formal representation for computational modelling, data selection, definition of objective functions, design or adjustment of algorithms, interpretation of computational results, and more. The randomization used in machine learning, such as the initial randomization of weights in artificial neural networks, should not be interpreted as an indication that AI systems exhibit self-determining behaviour since it is carried out by specialised computer programmes called “random number generators”.²²⁴ In this perspective, AI-related output is perceived as a seamless extension of human creativity.

For now, it appears plausible that the practitioner, who employs an AI system, is still actively making pertinent decisions concerning its selection and application, impacting the question of closeness to obviousness. The AI implements the human user’s instructions and processes the input in accordance with its programming.²²⁵ These are typically combinatory inventions: while their individual elements are already known in the prior art, a specific arrangement gives rise to a novel and non-obvious outcome.²²⁶ Although AI can employ so-called “technical randomness” or “pseudo-randomness” as a strategic search tool, it remains directed toward a specific problem to be solved. The AI-system does not generate a chance-based teaching in the human sense, but rather conducts a goal-directed search for solutions to predefined problems.²²⁷ An AI is capable of processing the entire body of prior art and, provided sufficient processing power, can independently compute the interactions of potential combinations of known and

²²¹ Daria Kim et al., ‘Ten Assumptions About Artificial Intelligence That Can Mislead Patent Law Analysis’ (2021 MPI Research Paper No. 21-18, 65 <https://ssrn.com/abstract=3910332>).

²²² Marc Hauser, *The Evolution of Communication* (MIT Press, 2000) 650.

²²³ Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 23.

²²⁴ Ibid.

²²⁵ Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 446 et seq. <https://doi.org/10.1093/grurint/ikaa061>, see also: ‘Request for Comments on Patenting Artificial Intelligence Inventions’, 84 Federal Register 44889 (2019) <https://www.federalregister.gov/documents/2019/08/27/2019-18443/request-for-comments-on-patenting-artificial-intelligence-inventions>.

²²⁶ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 397.

²²⁷ Ibid.

compatible elements.²²⁸ AI systems can be used to produce more quickly and productively, re-enact and assess huge quantities of potential results without the standard restrictions forced by human inclinations or time constraints.²²⁹ This is especially valuable in complex areas, where people face difficulty manually planning inventions, because of the complex nature, particularly where there are a variety of factors, as for example with nanotechnology and biotechnology.²³⁰

The human contribution still lies in defining the problem-solving pathway and intervening when necessary. As *Greenberg* emphasises, “machine learning algorithms learn from the data and come up with a final model spontaneously, the developer’s ingenuity still plays a major role”.²³¹ The human still chooses the AI method, “how to curate the training data, which algorithm parameters to select, and how to test the model for accuracy”, making the role of human in these systems fundamental. In such cases, both the human and the system can have an influence on the concrete form of the invention.²³² Also a recent study carried out by researchers from the Max Planck Institute for Innovation and Competition concluded that as long as a human is the one who conceives the overall computational process and provides instructions on how it should be executed, computers merely act as tools that assist human inventors.²³³ The researchers argue that this kind of assistance should not be considered more substantial in determining the allocation of inventor’s rights to a human compared to situations where other research tools or techniques are utilized during the invention development process.²³⁴

b) AI-Generated Inventions

“AI-generated” and “generated autonomously by AI” (Category V) are terms that are used interchangeably and refer to an output by AI with limited or without human intervention.²³⁵ “AI-generated” encompasses a broad range of systems and inventions, therefore a further differentiation is needed.

Category V inventions often include the work of evolutionary algorithms, which are capable of identifying optimal solutions tailored to specific environmental conditions.²³⁶ This can be

²²⁸ Ibid.

²²⁹ John R Koza, ‘Human-Competitive Results Produced by Genetic Programming’ (2010) 11 *Genetic Programming and Evolvable Machines* 251 <https://doi.org/10.1007/s10710-010-9112-3>.

²³⁰ Nicola Nosengo, ‘Can Artificial Intelligence Create the Next Wonder Material?’ (2016) 533 *Nature* 22–25 <https://www.nature.com/news/can-artificial-intelligence-create-the-next-wonder-material-1.19850>.

²³¹ Anastasia Greenberg, ‘Protecting Virtual Things: Patentability of Artificial Intelligence Technology for the Internet of Things’ (2020) 60(2) *IDEA: The Journal of Law and Technology* 334-335; Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 455 <https://doi.org/10.1093/grurint/ikaa061>.

²³² Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 398.

²³³ Ibid.

²³⁴ Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 5.

²³⁵ Ana P Gonzalez Torres, ‘AI-generated inventions: (A)I, inventor?’ (IusItinere, 27 April 2022) https://www.iusinitinere.it/ai-generated-inventions-ai-inventor-42263#_ftn9.

²³⁶ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 398.

illustrated with a simplified example: in each iteration, a set of potential solutions is generated, initially through pseudo-random processes. While none of the initial outputs are likely to represent viable solutions, some will perform better than others. The most successful candidates are then selected and varied slightly in the next round. The process continues until a solution no longer improves over successive iterations or meets predefined criteria.

This technique was employed in the design of an antenna for NASA's Space Technology 5 mission.²³⁷ The algorithm began with a basic wire structure already known in the prior art for its antenna function. Through successive modifications, bending the wire at arbitrary angles, the program generated between 50 and 200 candidate designs per iteration, each of which was simulated and assessed. The top-performing 50% were retained and modified slightly for the next generation. This process was repeated until the final design satisfied mission specifications.²³⁸ The resulting antenna significantly outperformed existing designs, while consisting of fewer components and being easier to manufacture.²³⁹ The novel curvature of the antenna led to a previously unknown and non-obvious effect, derived from a known physical object. Importantly, no human review or interpretation of intermediate results was necessary; only the final prototype was physically validated.²⁴⁰ The human contribution was limited to configuring the algorithm itself and defining the basic parameters, the actual inventive step in creating the effective antenna design came from the algorithm itself. The technical solution, in this case, was identified autonomously by the AI, which, given access to the entire corpus of prior art, was capable of recognising the suitability of a specific design, functionally mirroring human inventive behaviour. The algorithm produced a design that human engineers found surprising and would not have conceived on their own, yet it outperformed human-made designs. This suggests that the core inventiveness in this case can be attributed to the AI rather than direct human design input. If the antenna is classified as a use-related invention, it could be argued that a human, following a similar trial-and-error process, might have arrived at the same result. This suggests that computers, much like humans, are capable of generating inventions. The technologies discussed in this Section represent only a fraction of current AI research with the potential to generate new technical entities. Additional approaches, including those grounded in the Semantic Web and deep neural networks (commonly referred to as deep learning), are likely to gain comparable relevance in the context of autonomous invention.²⁴¹

As noted in the preceding section, AI systems are often categorised into three levels of autonomy: narrow AI, general AI, and superintelligent AI. It can be theorised that narrow AI is capable of semi-autonomous invention, general AI will be able to invent with a high degree of autonomy, and superintelligent AI will be capable of fully autonomous invention. Consequently, AI-generated inventions may be classified into three categories: semi-autonomously generated inventions, highly autonomously generated inventions, and fully autonomously generated inventions.

²³⁷ The procedure itself was, in turn, patented in the United States as US Patent Nr. 5,719,794.

²³⁸ Jason D Lohn, Gregory S Hornby and Derek S Linden, 'Human-competitive evolved antennas' (2008) 22(3) *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 235 et seq.

²³⁹ Ibid, 242.

²⁴⁰ Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für Geistiges Eigentum* 399.

²⁴¹ Ibid, 400.

Based on the current understanding, computers that act entirely independently do not exist yet. The degree of autonomy in AI systems may vary depending on one's definition of the term.²⁴² Still, the degree of human intervention required to qualify an AI output is subject to ongoing debate.²⁴³ At the moment a common opinion is that “characteristics such as ‘autonomous’, ‘unpredictable’ and ‘self-learning’ are ‘based on an overvaluation of the actual capabilities of even the most advanced robots, a superficial understanding of unpredictability and self-learning capacities [...], a robot perception distorted by science fiction and a few recent sensational press announcements’”.²⁴⁴ However, it is important to note that terms implying the complete absence of human influence can be more misleading than illuminating in this discussion. For now, the collaborative role of humans in the AI-driven inventive process remains significant.²⁴⁵

aa) Semi-Autonomously Generated Inventions

AI-assisted inventions are those developed by humans that use an AI system, whereas semi-autonomously generated inventions are those developed partly by humans and partly by AI systems in roughly equivalent parts.²⁴⁶ Whether such inventions can still be legally attributed to a human must be assessed on a case-by-case basis, depending on the extent and quality of the human's actual creative input. This permits a more nuanced subclassification based on the degree of human inventiveness, even though the boundaries between stages remain fluid.²⁴⁷

At the current state of the art, AI is said to be capable of generating semi-autonomously, meaning that the system is autonomous with regard to the execution (the “how”) of the creative task, but “what” is created is still based on a decision by the human.²⁴⁸ In this scenario, AI can change its behaviour during operation to respond to unanticipated information or events.²⁴⁹ The human plays a role in determining the overall concept and providing instructions, but the execution is carried out by the AI system.²⁵⁰

²⁴² The WIPO assumes such autonomy exists (WIPO, ‘Draft Issues Paper on Intellectual Property and Artificial Intelligence’ (WIPO/IP/AI/2/GE/20/1, 13 December 2019) https://www.wipo.int/about-ip/en/artificial_intelligence/call_for_comments/).

²⁴³ Compare Emir M Celik, ‘How IP Struggles to Define AI-Generated Products and the Ownership Dilemma’ (2020) 71(2) *Ankara Üniversitesi Hukuk Fakültesi Dergisi* 581.

²⁴⁴ Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 444 <https://doi.org/10.1093/grurint/ikaa061>.

²⁴⁵ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 7.

²⁴⁶ Christian Heinze and Andreas Engel, ‘KI und Patentrecht’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 81.

²⁴⁷ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 189-190.

²⁴⁸ Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 81-82; Alexandra George and Toby Walsh, ‘Can AI Invent?’ (2022) 4(12) *Nature Machine Intelligence* 1059, <https://www.nature.com/articles/s42256-022-00582-5>.

²⁴⁹ See Roman V Yampolskiy, ‘Analysis of Types of Self-Improving Software’ in J Bieger, B Goertzel, and A Potapov (eds), *Artificial General Intelligence* (Springer, Cham 2015) https://doi.org/10.1007/978-3-319-21365-1_39.

²⁵⁰ Joseph Straus, ‘Will Artificial Intelligence Change Some Patent Law Paradigms?’ (2021) *Zbornik znanstvenih razprav / Univerza v Ljubljani, Pravna Fakulteta (Collection of Scientific Papers / University of Ljubljana, Faculty of Law)* 17.

While the human can provide general guidelines and objectives, the actual result produced by the AI system may still differ from the intended outcome and may require further refinement by the human. AI systems used for creative tasks, such as generative adversarial networks, are in fact bound by the instructions and limitations imposed by their design and programming, but it is possible for them to produce unexpected and seemingly novel outcomes.²⁵¹ Most creative tasks that current AI systems perform, at core, are based on the mathematical optimisation of data points.²⁵² Human creative input is especially prominent in the preparatory stage (conception phase) of computation and post-implementation refinement.²⁵³ Compared to AI-assisted inventions, the degree of inventiveness is higher.

Nonetheless, a critical issue arises concerning the level of specificity in human instructions, which directly impacts the extent of human influence on AI-related outputs.²⁵⁴ When input instructions lack precision and AI identifies patterns that humans might not have discerned, the connection between human direction and the resulting output diminishes. The inherent human limitations in processing vast amounts of data within a limited timeframe, as opposed to AI, can contribute to what is commonly referred to as the “black box” problem (see Section F.I.2.b).²⁵⁵ The explainability or interpretability of this process, an active area of research in the field of explainable AI, particularly hinges on the complexity of the model. This challenge is most pronounced in the case of deep neural networks due to their multitude of layers.²⁵⁶ Still, if the AI is viewed as a “black box” inventor, the process does not differ fundamentally from that of a commissioned invention. Instead of one or more individuals being tasked with independently solving a technical problem, the AI assumes that role.²⁵⁷ In this case, AI is not merely an auxiliary tool in the inventive process; it is capable of autonomously generating technical solutions that satisfy the patent law definition of an invention.

Since what is observable is merely the final inventive output, along with the fact that the AI played a substantive role in generating it, a practical approach is to assess the typology from

²⁵¹ The complexity of these systems often hinders users from fully grasping their behaviour. Models with identifiable inputs and outputs but with behaviour that is difficult to comprehend are typically referred to as black-box models. Conversely, white-box models are distinguished by their clear and easily interpretable behaviour. (Andrea Tocchetti and Marco Brambilla, ‘The Role of Human Knowledge in Explainable AI’ (2022) 7(7) *Data* 1 <https://doi.org/10.3390/data7070093>).

²⁵² At its core, mathematical optimization entails the selection of inputs from a given set of options to achieve the most optimal output for a specific problem. This technique is known for its robustness in conducting prescriptive analysis and is applied to efficiently resolve complex business problems by enabling rapid decision-making. (<https://www.turing.com/kb/comparison-of-mathematical-optimization-and-machine-learning> (‘Comparison of Mathematical Optimization and Machine Learning’ (Turing.com) <https://www.turing.com/kb/comparison-of-mathematical-optimization-and-machine-learning>)).

²⁵³ Andrea Tocchetti and Marco Brambilla, ‘The Role of Human Knowledge in Explainable AI’ (2022) 7(7) *Data* 9 <https://doi.org/10.3390/data7070093>.

²⁵⁴ See Josef Drexler et al., ‘Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective’ (MPI Research Paper No. 19-13, 10 October 2019) 10 et seq.

²⁵⁵ Ibid.

²⁵⁶ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 8.

²⁵⁷ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 400.

the perspective of the human contributor.²⁵⁸ The lower the human's creative input, the greater the weight assigned to the AI's inventive role.

bb) Highly-Autonomously Generated Inventions

This description of “highly-autonomously generated inventions” suggests that the AI system has a higher level of autonomy in the creation process, compared to “semi-autonomously generated inventions”.²⁵⁹ In these inventions the AI's creative input outweighs that of the human. In this scenario, the human user provides only the broad parameters for the AI system to work within, but the system is responsible for determining the specific process and form of the output. The AI determines not only the “how” but also the “what” is created within the given framework for a specific creation.²⁶⁰ This encompasses scenarios in which a human merely states: “AI, we need a more effective cure for bone cancer, go invent one”. The human only provides the AI with the end goal and the AI comes up with a new drug or therapy without any further input or instructions.²⁶¹ In such instances, the human still defines the problem and deploys the AI for the purpose of solution generation.²⁶² The result is not predictable by the human, as the AI system is making its own creative decisions and choices, within the constraints set by the human.²⁶³ A The highly autonomous AI would decide the process and the form of the output, not predictable by the human that initiated the process.²⁶⁴

There are documented cases in which AI has not simply acted upon a technical problem defined by a human user, but has instead independently recognised a technical challenge and devised an appropriate solution. In these instances, the AI system performs the entire inventive process with minimal human input, functioning in a largely autonomous manner.²⁶⁵ The machine makes its own decisions, meaning that it does not implement the specifications of the user or programmer, but carries out tasks autonomously.²⁶⁶ The inventions cannot be traced back to a human inventor nor, in most cases, be understood by such. To do so, a computer or machine

²⁵⁸ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 189-191.

²⁵⁹ Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 82.

²⁶⁰ Ibid.

²⁶¹ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 15; Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 446 et seq. <https://doi.org/10.1093/grurint/ikaa061>.

²⁶² Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 186.

²⁶³ To bridge the gap in comprehensibility between humans and black-box models, it is necessary to devise techniques that can effectively tackle the multifaceted challenge of explainability. These techniques should address the faithfulness and completeness of the explanations that represent the behaviour of the model, all while considering the interpreter's ability to understand it. (Andrea Tocchetti and Marco Brambilla, ‘The Role of Human Knowledge in Explainable AI’ (2022) 7(7) *Data* 6 et seq. <https://doi.org/10.3390/data7070093>).

²⁶⁴ Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 83 et seq.

²⁶⁵ Daniel Köhl, ‘Autonome KI-Programme als Erfinder im Patentrecht’ (2025) *GRUR* 632; Joel Nägerl, Benedikt Neuburger and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 340.

²⁶⁶ Patentable inventions are typically considered to stem from human intellectual efforts. However, patent law has evolved to acknowledge human inventors, a requirement based on the fact that there has always been at least one person involved in the invention process (Cyril Soans, ‘Some Absurd Presumptions in Patent Cases’ (1966) 10 *Patent, Trademark and Copyright Journal of Research and Education* 433-450).

must be equipped with an AI system that develops its own rules according to which it can produce works or inventions without human influence.²⁶⁷

A prominent example of AI systems exhibiting a relatively advanced degree of autonomy can be found in so-called “patent mining” algorithms. These were initially designed to analyse patent documents and automatically classify their underlying functional principles.²⁶⁸ However, in a modified form, such algorithms may also be employed to identify patterns within recorded inventions and to infer correlations between technical problems and associated solution strategies. *Hope et al.*, for instance, developed a system intended to assist development teams in generating innovative solutions for product optimisation.²⁶⁹ This approach categorises products and patents according to their function and subdivides them into the dimensions of “purpose” and “mechanism”. During use, a specific problem related to product development is input into the system, which then searches for analogical solutions.²⁷⁰ The proposed analogies are evaluated based on the degree of similarity in purpose and the degree of difference in the employed mechanism: the greater the purpose alignment and the more distinct the mechanism, the higher the analogy is ranked.²⁷¹

cc) Fully-Autonomously Generated Inventions

The next and last level would be fully autonomous generated inventions. At this level the AI system controls the entire process from the conception of the creation to the concrete implementation through its learned knowledge, without the user or the programmer having any controlling influence on it.²⁷² The invention is developed in the absence of any human creative contribution. The AI system is controlling the entire creative process and the AI is said to produce inventions independently of any human instruction, guidance, or oversight. The computer would be able to set itself a goal and execute it.²⁷³ AI would proactively approach the human and states: “By the way, I’ve invented a more effective cure for bone cancer”.²⁷⁴ Such

²⁶⁷ The potential for AI-driven systems to invent presents a significant and timely question about the necessity of human inventorship under patent law. Beyond the debate on whether non-human entities can be recognized as inventors in most jurisdictions, the core issue concerns whether individuals involved in designing, operating, and providing data to these systems might be excluded from inventorship rights. This is due to the increasing autonomy of AI systems in the invention process (Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 2).

²⁶⁸ Daniel Köhl, ‘Autonome KI-Programme als Erfinder im Patentrecht’ (2025) *GRUR* 632 et seq.

²⁶⁹ Tom Hope, Joel Chan, Aniket Kittur and Dafna Shahaf, ‘Accelerating Innovation through Analogy Mining’ in S Matwin, S Yu, F Farood (eds), *KDD’17: Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (Association of Computing Machinery 2017) 235 et seq.

²⁷⁰ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz – eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 398.

²⁷¹ *Ibid.*

²⁷² *Ibid.*

²⁷³ Research into generative adversarial networks is headed in this direction (Ian Goodfellow et al., ‘Generative Adversarial Nets’ 3(11) *Advances in Neural Information Processing Systems* 2672 et seq.; Niklas Maamar, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Tübingen 2021) 84).

²⁷⁴ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 186.

a system is today quite unimaginable at the state of current technology.²⁷⁵ The creation of such systems will likely require many more breakthroughs in AI research and development.

While there have been advancements in AI and machine learning, current AI systems still operate, at least to some degree, within the parameters set by their human creators, and they still require human input and guidance at least to some extent.²⁷⁶ Only when and if AI is able to invent things on its own without any input or guidance from humans, it can be considered truly autonomous. For this to be the case, the AI's output must not be influenced by the work of a human and the AI must act with self-determination.²⁷⁷

3. Complications with the Idea of “AI-Related” Inventions

The concept of AI-related inventions is accompanied by technical difficulties. For instance, it may be challenging to pinpoint the precise procedures that lead to the invention and to confirm that it was created automatically, with or without human input.²⁷⁸ The technological difficulties with the idea of “AI-related” inventions have to do mainly with the problem of how to credit inventive work to AI systems. To evaluate whether AI systems are capable of producing truly innovative and non-obvious inventions, a number of technical questions must be answered.

The first difficulty is figuring out the precise process by which AI systems produce inventions, which is a central issue in the determination of the inventive step. AI systems do not have conscious minds or intentions like human inventors do. This makes it challenging to distinguish between an AI-related idea that is actually creative and one that is simply the outcome of the AI system analysing already-existing information and data. To address this, several approaches can be implemented. Improved explainability and transparency can be achieved by developing and implementing “explainable AI” techniques to make the decision-making processes of AI

²⁷⁵ Joseph Straus, ‘Some Lessons from “DABUS” Patent Applications’ in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli, Turin 2021) 624-625; Noam Shemtov, ‘A study on inventorship in inventions involving AI activity’ (Commissioned by the EPO, February 2019) 22 [http://documents.epo.org/projects/babylon/eponet.nsf/0/3918F57B010A3540C125841900280653/\\$File/Concept_of_Inventorship_in_Inventions_involving_AI_Activity_en.pdf](http://documents.epo.org/projects/babylon/eponet.nsf/0/3918F57B010A3540C125841900280653/$File/Concept_of_Inventorship_in_Inventions_involving_AI_Activity_en.pdf) (stating that AI systems designed to autonomously generate useful information currently do not seem to be available and are unlikely to become feasible in the near to mid-term future); Cesare Galli and Mariangela Boggi, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) *Il Diritto industriale* 129; Dan L Burk, ‘AI Patents and the Self-Assembling Machine’ (2021) 105 *Minnesota Law Review Headnotes* 317 (stating that classifying AI tools as either inventors or infringers is [...] absurd).

²⁷⁶ On the current debate see: Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 5.

²⁷⁷ See for example: Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 2 et seq; Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 7-8; Rose Hughes, ‘Is it time to move on from the AI inventor debate?’ (IPKat, 2 December 2020) <https://ipkitten.blogspot.com/2020/12/is-it-time-to-move-on-from-ai-inventor.html>.

²⁷⁸ Daria Kim, ‘AI-Generated Inventions: Time to Get the Record Straight?’ (2020) *GRUR International* 445 et seq.

systems more transparent.²⁷⁹ Additionally, continuous monitoring and auditing processes can be established to ensure AI systems remain fair and unbiased as they learn and improve over time. Maintaining human oversight in the inventive process can also be crucial, using AI as a tool to augment human creativity rather than replace it entirely.

The second difficulty is ensuring that AI systems remain impartial and unaffected by outside forces. This can happen when the AI system is built to prefer particular outcomes over others, or it can happen when the training data used to teach the AI system is biased.²⁸⁰ To retain the integrity of the creative process and to guarantee that AI-related ideas are truly innovative and non-obvious, it is crucial to ensure that AI systems are as bias-free as possible.²⁸¹ Several strategies can be employed to address this issue. First, it is essential to ensure that the training data used for AI systems is diverse, representative, and as free from bias as possible.²⁸² Implementing robust bias detection methods and mitigation strategies throughout the AI development lifecycle is also important. Furthermore, fostering diversity in AI development teams can help catch different types of bias by including people from various backgrounds.²⁸³

Given the ambiguous and evolving technological landscape surrounding AI-assisted and AI-generated inventions, drawing a clear distinction between the two remains challenging. From a patent law perspective, this raises the question of whether the current standards for assessing patentability, particularly the inventive step requirement, are adequate for addressing both categories of inventions, irrespective of a strict classification. The issue is marked by a certain degree of urgency, warranting a proactive reassessment of the legal framework to ensure its responsiveness to developments in AI innovation. It may not be AI that must conform to the existing patent framework.²⁸⁴ Rather, in view of the broader objective of technology law to foster an environment conducive to technological progress, it may be necessary to adapt the framework itself. This is especially pressing given AI's projected transformative impact across industries and its role in shaping the future trajectory of innovation.²⁸⁵

²⁷⁹ For a more detailed examination of “explainable AI” see: Wojciech Samek and Klaus-Robert Müller, ‘Towards Explainable Artificial Intelligence’ in W Samek and others (eds), *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning* (Berlin and Heidelberg 2019) 5-6.

²⁸⁰ Nadejda Alkhaldi, ‘What Is AI Bias Really, and How Can You Combat It?’ (ITRex, 27 August 2024) <https://itrexgroup.com/blog/ai-bias-definition-types-examples-debiasing-strategies/>.

²⁸¹ Frank Ginac, ‘The Impossible Goal: Bias-Free AI’ (IHRIM, 15 September 2021) <https://www.ihrim.org/2021/09/the-impossible-goal-bias-free-ai-by-frank-ginac/>.

²⁸² Jasmin Link, Helena Dadakou and Anne Elisabeth Krüger, ‘Lowering the Risk of Bias in AI Applications’ (2023) 72 *Artificial Intelligence and Social Computing* 181 et seq., https://openaccess.cms-conferences.org/publications/book/978-1-958651-48-3/article/978-1-958651-48-3_18.

²⁸³ Ibid.

²⁸⁴ Martin Stierle, ‘A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System’ (2021) *GRUR International* 119; Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 340; Yann Ménière and Heli Pihlajamaa, ‘Künstliche Intelligenz in der Praxis des EPA’ (2019) *GRUR* 232 et seq.

²⁸⁵ On different functions of technology law, the first being influencing the creation of technology, see: Herbert Zech, ‘Life Sciences and Intellectual Property: Technology Law Put to the Test’ (2015) *Zeitschrift für Geistiges Eigentum* 3.

4. Preliminary Results

The categorisation of AI outputs plays a crucial role in understanding AI-related inventions. These inventions can be broadly divided into two groups: those where AI forms part of the invention's mechanism (Categories I-III) and those designed, assisted, or made by AI (Categories IV-V). The latter group, which is the focus of this thesis, involves inventions created with AI's assistance or autonomy, but where AI is not necessarily part of the invention's mechanism. Categories IV and V focus on the role AI plays in the inventive process, and the level of human involvement, particularly in distinguishing between AI-assisted and AI-generated inventions.

In Category IV, AI is used as a tool by a human inventor to address specific problems, with humans playing a key role in selecting the AI methods, training data, and defining the problem. AI systems assist by producing inventive solutions, often addressing issues that were not initially intended. Category V, in contrast, involves inventions (equally, predominantly or completely) autonomously generated by AI, where human involvement may be limited to initiating the process or non-significant. The AI operates with greater independence, leading to new and inventive outputs without direct human intervention.

Category V inventions can be further classified according to the degree of autonomy exhibited by the AI system: semi-autonomous, highly autonomous, and fully autonomous. In semi-autonomous inventions, the inventive contribution is shared relatively equally between the human and the AI system. Typically, the human defines the overarching objective, while the AI system performs the substantive execution. In highly autonomous inventions, the inventive process is predominantly driven by the AI, with only limited human input. In such cases, the AI determines both the method and the result. Fully autonomous inventions, still hypothetical given current technological capabilities, are characterised by the AI independently setting its own objectives and carrying out the inventive process without any human intervention.

The technological difficulties surrounding AI-related inventions related to challenges in attributing inventive work to AI systems. First, it is difficult to determine the exact process by which AI systems produce inventive outcomes, raising issues of transparency and explainability in assessing whether an AI invention is truly innovative. Second, there are concerns about the potential for bias in AI-related inventions, either from biased training data or from the AI system itself. Ensuring fairness and transparency through improved AI explainability and human oversight remains crucial in mitigating these challenges.

IV. Promising Sectors for the Use of AI to Generate Inventions

When it comes to AI-related inventions, classic examples include *Thaler's* Creative Machine²⁸⁶ with the CrossAction toothbrush design²⁸⁷ and the DABUS inventions,²⁸⁸ *Koza* and Genetic programming,²⁸⁹ and the NASA space antenna design by *Lohn* and his team.²⁹⁰ Still, the most promising progresses are in the pharmaceutical and medical field. AI is being used, amongst others, for tasks such as drug discovery, protein engineering, gene editing, and personalized medicine.²⁹¹ It can help researchers analyse large amounts of data, identify patterns, and make predictions, which can lead to more efficient and effective research. Several companies are investing heavily in AI applications and many start-ups have emerged in recent years specifically focused on AI-driven drug discovery.²⁹²

1. The Pharmaceutical Industry

a) The Role of AI in Pharmaceutical Research and Development

The idea behind the use of AI applications in the pharmaceutical industry is to simplify complexity and bring out potential lines of research that otherwise researchers would hardly be able to identify “with the naked eye”.²⁹³ The whole process is conditioned by the human limit in managing and screening large amounts of data.²⁹⁴ To overcome these limitations, many pharmaceutical companies are exploring and, in some cases, applying the use of AI in the different stages of drug research and development.²⁹⁵ While AI is expected to play an

²⁸⁶ Artificial Inventor, ‘The Artificial Inventor Project’ <https://artificialinventor.com/>; Imagination Engines Inc., ‘IEI’s Patented Creativity Machine® Paradigm’ <https://imagination-engines.com/cm.html>.

²⁸⁷ Robert Plotkin, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business* (Stanford University Press 2009) 51 et seq.; Ana Ramalho, *Intellectual Property Protection for AI-generated Creations: Europe, United States, Australia and Japan* (Routledge 2021) 83.

²⁸⁸ For a recent profile on *Thaler*, see: Tomas Weber, ‘The Inventor Who Fell in Love with His AI’ (1843 Magazine, The Economist, 4 April 2023) <https://www.economist.com/1843/2023/04/04/the-inventor-who-fell-in-love-with-his-ai>.

²⁸⁹ Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1087-1088; Mark Summerfield, ‘The Impact of Machine Learning on Patent Law, Part 2: Machine-Assisted Inventing’ (Patentology, 21 January 2018) https://blog.patentology.com.au/2018/01/the-impact-of-machine-learning-on_21.html.

²⁹⁰ Gregory Hornby et al., ‘Automated Antenna Design with Evolutionary Algorithms’ (2006) AIAA 2006-7242, Space 2006 <https://arc.aiaa.org/doi/10.2514/6.2006-7242>; NASA, ‘Intelligent Agents: A Technology and Business Applications Analysis’ (NASA Technical Reports Server, 2006) <https://ntrs.nasa.gov/citations/20060024675>.

²⁹¹ Robert P Merges and John F Duffy, *Patent Law and Policy* (8th edn, Carolina Academic Press 2021) 519.

²⁹² Some companies that are known to use AI in the biotech industry include: Insilico Medicine, Recursion Pharmaceuticals, BenevolentAI, Ginkgo Bioworks, Atomwise, Zymergen, XtalPi, Numerate, BioSymetrics, and BERG.

²⁹³ Włodzisław Duch et al., ‘Artificial Intelligence Approaches for Rational Drug Design and Discovery’ (2007) 13(14) *Current Pharmaceutical Design* 1497 et seq.; Jane P Hughes et al., ‘Principles of Early Drug Discovery’ (2011) 162(6) *British Journal of Pharmacology* 1239 et seq.

²⁹⁴ Jackie Hunter, ‘Adopting AI is essential for a sustainable pharma industry’ (2016) *Drug Discovery World* 70 et seq.

²⁹⁵ In the last decade, several collaborations have been formed between major pharmaceutical and biotech operators and companies led by artificial intelligence, especially start-ups to discover new biological targets and molecules for pharmacists who use artificial intelligence. For example, in 2017 GlaxoSmithKline worked with two external companies - Exscientia, a UK-based auto-learning specialist, and Insilico Medicine, a US-based leader in the discovery of artificial intelligence-driven drugs - to exploit artificial intelligence. Also in the pharmaceutical

increasingly important role in pharmaceutical research and development, most researchers are still cautious in describing the capabilities and challenges associated with the use of AI.²⁹⁶

Pharmaceutical inventions require more investments than other types of inventions to reach the market.²⁹⁷ The cost of bringing a new drug to market is estimated to be around USD 1.2-2.3 billion on average, and the marketing authorization requirements are rigorous, with around 90% of new drugs failing to be approved by authorities.²⁹⁸ The process of discovering a new drug is long and expensive, involving several phases from basic research to clinical trials, which can take between ten and fifteen years to complete.²⁹⁹ The drug discovery process is complex and starts with basic research to identify the molecular targets of a disease and molecules that can interact with them.³⁰⁰ This is followed by pre-clinical and clinical trials to investigate the safety and efficacy of the product.³⁰¹ Of particular importance at present is the optimization of resources within trials. This encompasses aspects ranging from the formulation of trial designs, initiation with the allocation of resources, trial execution, and eventual conclusion.

division of Roche Holdings, Genentech, the company has entered into a research partnership with Gns Healthcare to promote cancer drug development with the Refs learning and simulation platform of the Ia. AstraZeneca also partnered with Berg of Boston last year to use artificial intelligence to discover new targets and therapies for the treatment of neurological disorders such as Parkinson's disease. Boston pharma startup Berg also uses an artificial intelligence to analyse terabytes of cancer data. Johnson & Johnson, Pfizer and Novartis work with IBM's Watson Health unit to leverage artificial intelligence's solutions and applications for drug discovery and primarily accelerate cancer research. With the use of artificial intelligence, it is estimated that drug design times can be reduced from 4-5 years to one year, drastically reducing costs. Although artificial intelligence is still in its early stages of use in biotechnology for drug discovery and other purposes, it is expected to be adopted on a large scale. (João Medeiros, 'The Startup Fighting Cancer with AI' (Wired, 22 March 2016) <https://www.wired.co.uk/article/ai-cancer-drugs-berg-pharma-startup>; Imogen Ireland, 'The Skilled Machines Disrupting Drug Design' (Hogan Lovells Publications, October 2019) <https://www.hoganlovells.com/en/publications/the-skilled-machines-disrupting-drug-design>).

²⁹⁶ On the role of AI in pharma see, for example: João Medeiros, 'The Startup Fighting Cancer with AI' (Wired, 22 March 2016) <https://www.wired.co.uk/article/ai-cancer-drugs-berg-pharma-startup>; Michael A Kiebish et al., 'Bayesian Model Infers Drug Repurposing Candidates for Treatment of COVID-19' (2021) 11(6) *Applied Sciences* 2466; Peter Richardson et al., 'Baricitinib as Potential Treatment for 2019-nCoV Acute Respiratory Disease' (2020) 395(10223) *The Lancet* e30; Kathleen Walch, 'The Increasing Use Of AI In The Pharmaceutical Industry' (Forbes, 26 December 2020) <https://www.forbes.com/sites/cognitiveworld/2020/12/26/the-increasing-use-of-ai-in-the-pharmaceutical-industry/?sh=21e81f474c01>.

²⁹⁷ Giorgio Sirilli, 'Patents and Inventors: An Empirical Study' (1987) 16 *Research Policy* 164 et seq.; Mark A Lemley, 'Reconceiving Patents in the Age of Venture Capital' (2000) 4 *Journal of Small & Emerging Business Law* 137 et seq.

²⁹⁸ Olivier J Wouters, Martin McKee and Jeroen Luyten, 'Estimated Research and Development Investment Needed to Bring a New Medicine to Market, 2009-2018' (2020) 323(9) *JAMA* 844; Joseph A DiMasi, Henry G Grabowski and Ronald W Hansen, 'Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs' (2016) 47 *Journal of Health Economics* 20; Olga Gurgula, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 2 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3683127.

²⁹⁹ Olga Gurgula, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 2; EFPIA, *The Pharmaceutical Industry in Figures* (2021) 6 www.efpia.eu/media/602709/the-pharmaceutical-industry-in-figures-2021.pdf.

³⁰⁰ Kit-Kay Mak and Mallikarjuna Rao Pichika, 'Artificial Intelligence in Drug Development: Present Status and Future Prospects' (2019) 24(3) *Drug Discovery Today* 773; UNCTAD, *The Role of Competition in the Pharmaceutical Sector and Its Benefits for Consumers* (2015) TD/RBP/CONF.8/3, 3 https://unctad.org/system/files/official-document/tdrbpconf8d3_en.pdf.

³⁰¹ For a general overview on AI and the pharmaceutical sector see: Olga Gurgula, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 2 et seq.

Depending on the different objectives, AI applied to drug research and development, integrated with machine learning and data mining skills, allows processes based on reasoning (ability to solve problems on the basis of logical deduction), knowledge (understanding of specific entities within the context), planning (ability to reach a goal), communication (ability to understand written and verbal language), perception (ability to deduce on the basis of visual or auditory sensory inputs).³⁰² AI offers powerful tools to computer-aided drug design, including finding new disease-associated molecular targets, screening molecule libraries to find new drug candidates, designing new compounds, optimizing drug candidates by identifying their potential toxic side effects, repurposing existing drugs for new applications, and improving the modelling of pre-clinical tests.³⁰³ AI can also examine published scientific materials and cross-reference them with other resources, such as the results of clinical trials.³⁰⁴ The new technology also makes it possible to collect and standardise data from different sources more quickly. This means that unstructured text is converted into analysable data using natural language processing technology. Cloud and big data technologies can be used to access more and more data that can be used to optimise drug development.³⁰⁵ This data enables machine learning and allows correlations to be identified more quickly, patterns to be defined and forecasts to be made to make more effective and intelligent decisions.³⁰⁶

³⁰² Big data holds the potential to unlock new insights and accelerate discoveries. However, despite the abundance of available data, only a small portion is being effectively integrated, understood, and analysed. The main challenge lies in managing vast amounts of data, integrating it from numerous sources, and deciphering its diverse formats. Cognitive computing technologies offer a promising solution to this challenge, as they are specifically designed to integrate and analyse large datasets. These cognitive solutions can interpret various types of data, such as structured lab values or unstructured text from scientific publications. They are trained to understand industry-specific content and utilize advanced reasoning, predictive modelling, and machine learning to expedite research. Watson, a cognitive computing technology, has been adapted to support life sciences research, incorporating medical literature, patents, genomics, and chemical and pharmacological data. Watson is equipped with an understanding of scientific terminology, enabling it to discover novel connections within vast amounts of text. It has been applied in pilot studies for drug target identification and drug repurposing, with results indicating that Watson can accelerate the discovery of new drug candidates and targets by leveraging big data (Ying Chen, Elenee Argentinis and Griff Weber, 'IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research' (2016) 38(4) *Clinical Therapeutics* 688 et seq.).

³⁰³ Rajesh K Pathak et al., 'Computational Approaches in Drug Discovery and Design' in Dev Bukhsh Singh (ed), *Computer-Aided Drug Design* (Berlin and Heidelberg 2020) 2.

³⁰⁴ Viseven, 'Artificial Intelligence in Pharma Industry' (Viseven, 2024) <https://viseven.com/artificial-intelligence-in-pharma-industry/#:~:text=AI%20helps%20to%20apply%20machine,treatment%20methods%20for%20rare%20diseases.>

³⁰⁵ On the use of big data in AI see: Ryan Abbott, 'Hal the Inventor: Big Data and Its Use by Artificial Intelligence' in Cassidy R Sugimoto, Hamid Ekbil and Michael Mattioli (eds), *Big data is not a monolith* (MIT Press 2016) 194.

³⁰⁶ GNS Healthcare, 'GNS Healthcare Announces Collaboration to Power Cancer Drug Development with REFS™ Causal Machine Learning and Simulation AI Platform' (GNS Healthcare, 19 July 2019) <https://www.gnshealthcare.com/gns-healthcare-announces-collaboration-to-power-cancer-drug-development/>; Daniel Faggella, 'Machine Learning Drug Discovery Applications – Pfizer, Roche, GSK, and More' (Emerj, Business Intelligence and Analytics, 2 February 2019) <https://emerj.com/ai-sector-overviews/machine-learning-drug-discovery-applications-pfizer-roche-gsk/>; Nic Fleming, 'How Artificial Intelligence is Changing Drug Discovery' (2018) 557 *Nature* 55-57.

b) Applications of AI Across the Drug Development Pipeline

AI tools, such as “computer-aided drug design”, have been recognized as a potential means to accelerate drug development.³⁰⁷ AI can be used in various stages and ways from the manufacturing process to drug development and discovery, diagnostic assistance, personalised treatment, and clinical trials. Employing advanced data analytics, improved biosensors, and interconnected devices, AI enhances the likelihood of success within clinical trials. Many pharmaceutical companies now depend on AI to identify suitable candidates for clinical trials. By collecting and analysing data on factors such as the existing diseases within the target population, demographic specifics, and infection rates, AI technology assists in forming appropriate testing groups, leading to successful drug trials. This significantly improves drug adherence and broadens opportunities for repurposing existing medications. Researchers could replace human-based studies with computer-based tests and thus significantly reduce the potential risk to volunteers in terms of drug dosage during Phase I studies. In addition, AI makes it possible to predict the risk of how faithful volunteers are to their therapy and how high the probability is that they will abandon the study.³⁰⁸

AI can significantly increase the speed and accuracy of research, resulting in more effective and efficient answers to challenging issues. For example, finding drug candidates requires a thorough understanding of the complex human biological system, and only one or two out of every 10.000 potential drug-like molecules will successfully pass all stages of development and make it to the market.³⁰⁹ Only 10% of the compounds entering Phase 1 of clinical development reach the next phase and the failure rate in phases 2 and 3 is over 50%, unchanged for more than two decades.³¹⁰ Half of the failures are due to lack of efficacy, an expression of the difficulty of selecting the right target for the disease being studied.³¹¹ Moreover, most drugs that pass this last stage do not receive approval by the competent supervisory authority, typically because of lack of efficacy and/or safety.³¹² AI systems can be applied to solve the

³⁰⁷ Gisbert Schneider, ‘Mind and Machine in Drug Design’ (2019) 1 *Nature Machine Intelligence* 128; Matthew A Sellwood et al., ‘Artificial Intelligence in Drug Discovery’ (2018) 10(17) *Future Medicinal Chemistry* 2025; Tanja Dimitrov et al., ‘Autonomous Molecular Design: Then and Now’ (2019) 11(28) *ACS Applied Materials & Interfaces* 24825 et seq.

³⁰⁸ Nic Fleming, ‘How Artificial Intelligence is Changing Drug Discovery’ (2018) 557 *Nature* 55-57; GNS Healthcare, ‘GNS Healthcare Announces Collaboration to Power Cancer Drug Development with REFS™ Causal Machine Learning and Simulation AI Platform’ (GNS Healthcare, 19 July 2019) <https://www.gnshealthcare.com/gns-healthcare-announces-collaboration-to-power-cancer-drug-development/>; Daniel Faggella, ‘Machine Learning Drug Discovery Applications – Pfizer, Roche, GSK, and More’ (Emerj, Business Intelligence and Analytics, 2 February 2019) <https://emerj.com/ai-sector-overviews/machine-learning-drug-discovery-applications-pfizer-roche-gsk/>.

³⁰⁹ David Rotman, ‘Reinvent How We Invent’ (MIT Technology Review, 15 February 2019); Bowen Lou and Lynn Wu, ‘Artificial Intelligence and Drug Innovation: A Large Scale Examination of the Pharmaceutical Industry’ (2021) 45(3) *Management Information Systems Quarterly* 1457.

³¹⁰ The reason for such late-stage failures is typically due to clinical safety and efficacy, followed by formulation, pharmacokinetics, bioavailability and toxicity analysis. About 62% of new chemical entities do not reach the clinical trial stage: see Kit-Kay Mak and Mallikarjuna Rao Pichika, ‘Artificial Intelligence in Drug Development: Present Status and Future Prospects’ (2019) 24(3) *Drug Discovery Today* 775.

³¹¹ Jackie Hunter, ‘Adopting AI is essential for a sustainable pharma industry’ (2016) *Drug Discovery World* 70 et seq.

³¹² Manfred E Wolff, ‘Drug Discovery Market Exclusivity After KSR: The Challenge to Pharmaceutical Scientists and the US Congress’ (2011) 100(8) *Journal of Pharmaceutical Sciences* 3047; Ying Chen, Elenee Argentinis and Griff Weber, ‘IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research’ (2016) 38(4) *Clinical Therapeutics* 688 et seq.; Ismail Kola and John Landis, ‘Can the Pharmaceutical

mentioned problems and are said to revolutionising drug development.³¹³ AI systems are increasingly seen as a solution to many of the challenges faced in drug development, including the high costs and long timelines.³¹⁴

AI is also used for drug repurposing, where existing drugs are evaluated for new indications.³¹⁵ AI tools can identify the molecular mechanisms of drugs and match them with potential new indications, leading to the discovery of new uses for existing drugs.³¹⁶ These activities reduce the cost and time required for drug development and increase the efficiency and accuracy of the drug discovery process.

c) Industrial Integration, Case Studies and the Role of Patents

Major pharmaceutical companies, including Novartis, Roche, Pfizer, Merck, AstraZeneca, GlaxoSmithKline, Sanofi, Abbvie, Bristol-Myers Squibb, and Johnson & Johnson, have actively engaged in collaborations or acquisitions related to AI technologies to harness the potential benefits it offers.³¹⁷ While companies within the life sciences sector may not be pioneers in AI advancement, they recognize substantial potential for the integration of such technology across all phases of drug and treatment research, as well as the subsequent commercialization processes.³¹⁸ Many large pharmaceutical companies have formed joint ventures and partnerships with startups specialising in AI-based drug discovery.³¹⁹ Other pharmaceutical companies have established internal departments dedicated to the entire

Industry Reduce Attrition Rates?’ (2004) 3(8) *Nature Reviews Drug Discovery* 715; Mwango Kashoki et al., ‘A Comparison of EMA and FDA Decisions for New Drug Marketing Applications 2014–2016: Concordance, Discordance, and Why’ (2020) 107(1) *Clinical Pharmacology & Therapeutics* 195 et seq.; Giovanni Tafuri et al., ‘Disclosure of Grounds of European Withdrawn and Refused Applications: A Step Forward on Regulatory Transparency’ (2013) 75(4) *British Journal of Clinical Pharmacology* 1149 et seq.

³¹³ Paul Workman, Albert A Antolin and Bissan Al-Lazikani, ‘Transforming Cancer Drug Discovery with Big Data and AI’ (2019) 14(11) *Expert Opinion on Drug Discovery* 1091.

³¹⁴ Kevin Williams et al., ‘Cheaper Faster Drug Development Validated by the Repositioning of Drugs Against Neglected Tropical Diseases’ (2015) 12(104) *Journal of the Royal Society* <http://rsif.royalsocietypublishing.org/content/12/104/20141289>.

³¹⁵ Vincenzo Salvatore and Vivian G Chammah, ‘Advancing Clinical Trials through Artificial Intelligence: A Legal Perspective’ (2020) 12(6) *Journal of Clinical Studies* 44; Nicholas J Schork, ‘Artificial Intelligence and Personalized Medicine’ (2019) 178 *Cancer Treatment and Research* 265.

³¹⁶ Francesca Properzi et al., ‘Intelligent drug discovery, Powered by AI’ (Deloitte Insights, 2019) www2.deloitte.com/us/en/insights/industry/life-sciences/artificial-intelligence-biopharma-intelligent-drug-discovery.html.

³¹⁷ Iolanda Bulgaru, ‘Pharma Industry in the Age of Artificial Intelligence: The Future is Bright’ *Healthcare Weekly* (18 March 2019) <https://healthcareweekly.com/artificial-intelligence-in-pharmacology/>.

³¹⁸ Peter R Thomsen et al., ‘AI in Biopharma Research: A Time to Focus and Scale’ (McKinsey, 10 October 2022) 2 <https://www.mckinsey.com/industries/life-sciences/our-insights/ai-in-biopharma-research-a-time-to-focus-and-scale>; Novartis, ‘Artificial Intelligence’ <https://www.novartis.com/about/strategy/data-and-digital/artificial-intelligence>.

³¹⁹ For example, Novartis has joined forces with Microsoft, leveraging their expertise in information technology to bolster AI capabilities. This strategic alliance is essential as Novartis acknowledges the profound challenges posed by the digital era and AI to their conventional life sciences business model, particularly from the perspective of intellectual property (Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 10 <https://ssrn.com/abstract=4122985>; Debleena Paul et al., ‘Artificial Intelligence in Drug Discovery and Development’ (2021) 26(1) *Drug Discovery Today* 81; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 67 <https://hdl.handle.net/11565/4062472>).

development process of AI technologies. This diversity in approaches reflects the dynamic landscape of AI integration within the pharmaceutical industry.³²⁰

For example, in 2020, Pfizer and Insilico Medicine announced a collaboration to use AI to accelerate the drug discovery process for potential cancer treatments, and in 2021, the Food and Drug Administration (FDA) approved an AI-based tool developed by Caption Health that helps medical professionals interpret ultrasound images. Countless other collaborations of this kind followed with the goal to for example use AI for target-based and phenotypic drug discovery, for the processing of biomedical, clinical, and patient data and for biomarker development.³²¹ In July 2023, The Institute of Cancer Research in London announced a collaboration with the Bellvitge Biomedical Research Institute and Vivan Therapeutics to use AI for designing precision cancer drugs targeting the challenging KRAS protein. This partnership seeks to create new therapies that can effectively address drug resistance, improving the chances of successful cancer treatment.³²²

In 2020, an AI-based system at the Collins Lab identified a highly effective antibiotic *Halicin*, a JNK enzyme inhibitor.³²³ The system used an analytical approach by learning representations of molecules and designing molecular representations that were highly tuned to the desired property, which allowed for the identification of structurally different antibiotics.³²⁴ The system was given the task of finding a compound with a specific property related to *E.coli*, which hospitalizes thousands of people a year, as well as an antibiotic-resistant strain of another common bacterial infection, *Acinetobacter baumannii*.³²⁵ The system successfully ranked *Halicin* as the leading solution, which no human involved in the process could control or predict beforehand.³²⁶ Even more interestingly, lab retrained the original deep learning model which later led to the identification of the antibiotic properties of *Abaucin*, a molecule previously

³²⁰ Francesca Mazzi, 'Patentability of AI Generated Drugs' (2020) 4(1) *EPLR* 17-19 <https://doi.org/10.21552/eplr/2020/1/5>.

³²¹ Tom Simonite, 'Software Dreams Up New Molecules in Quest for Wonder Drugs' (MIT Technology Review, 3 November 2016) <https://www.technologyreview.com/s/602756/software-dreams-up-new-molecules-in-quest-for-wonder-drugs/>.

³²² 'New AI Drug Discovery Collaboration Aims to Design New Precision Cancer Drugs' (The Institute of Cancer Research, 13 July 2023) <https://www.icr.ac.uk/news-archive/new-ai-drug-discovery-collaboration-aims-to-design-new-precision-cancer-drugs>.

³²³ Shota Higashihira et al., 'Halicin Is Effective Against Staphylococcus aureus Biofilms In Vitro' (2022) 480(8) *Clinical Orthopaedics and Related Research* 1476; Zubair Hussain et al., 'Study on Antibacterial Effect of Halicin (SU3327) against Enterococcus faecalis and Enterococcus faecium' (2022) 80(1) *Pathogens and Disease* 1 et seq.; Rayan Y Booq et al., 'Assessment of the Antibacterial Efficacy of Halicin Against Pathogenic Bacteria' (2021) 10, 12 *Antibiotics* 1480; Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 68 et seq.

³²⁴ Jonathan M Stokes et al., 'A Deep Learning Approach to Antibiotic Discovery' (2020) 180 *Cell* 688, 689 <https://www.cell.com/cell/pdf/S0092-8674%2820%2930102-1.pdf>.

³²⁵ Giovanni Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 45-46.

³²⁶ While the researchers behind Halicin initially suggested that its discovery was not due to human involvement, this assertion is incorrect. The process leading to Halicin's discovery involved considerable human effort. The paper documenting this discovery credits 20 authors from renowned research institutions. They developed a dataset of 2,335 molecules and employed a deep neural network to evaluate a library of 6,111 molecules for potential antibiotics. This approach led to the identification of Halicin as the most promising candidate. (Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 49-50; Joseph Straus, 'Some Lessons from "DABUS" Patent Applications' in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli 2021) 634; Jonathan M Stokes et al., 'A Deep Learning Approach to Antibiotic Discovery' (2020) 180 *Cell* 688-691).

investigated as a protein CCR2 antagonist, against *A. baumannii*, a highly resistant pathogen. This breakthrough was achieved using a similar deep learning screening and testing model.³²⁷

Another example is the biopharmaceutical company Berg that employed its Interrogative Biology® AI platform to analyse samples, successfully identifying a potential drug for treating multiple cancer types and epidermolysis bullosa, which is currently in Phase I/II clinical trials. Berg's team also released a research paper on drug repurposing for SARS-CoV-2, highlighting the application of machine learning techniques, such as Bayesian networks. Similarly, BenevolentAI, a key player in this field, developed a deep learning platform designed to analyse scholarly literature, patents, patient data, and clinical trial documents to predict interactions between chemical and biological entities and identify drug candidates. In April 2020, BenevolentAI identified Olumiant (baricitinib), a drug from Eli Lilly, as a potential treatment for SARS-CoV-2, leading to its FDA emergency use authorization in the US, while the European Medicines Agency also initiated investigations into its possible use.

Given these developments, patents play an essential role in fostering pharmaceutical innovation, enabling companies to protect their AI-driven breakthroughs and recoup significant investments in research and development.³²⁸ It is commonly argued that without patent exclusivity, no pharmaceutical company would invest in finding solutions to unmet clinical needs.³²⁹ Reverse engineering and manufacturing of generic drugs are relatively cheap, which is why patent exclusivity is important to incentivize pharmaceutical companies to continue investing in cutting-edge research and development.³³⁰

The pharmaceutical industry has relied on computational methods in drug design, including AI, for decades, but due to a drastic increase in the digitalization of pharmaceutical data, AI offers more powerful tools than ever before to computer-aided drug design.³³¹ Despite legal scholars' expectations, there has been no miraculous progress in drug discovery as a result of AI.³³² Still,

³²⁷ Gary Liu et al., 'Deep Learning-Guided Discovery of an Antibiotic Targeting *Acinetobacter baumannii*' (2023) 19 *Nature Chemical Biology* 1342 et seq., <https://doi.org/10.1038/s41589-023-01349-8>.

³²⁸ Fred D Ledley et al., 'Profitability of Large Pharmaceutical Companies Compared With Other Large Public Companies' (2020) 323 *JAMA* 834.

³²⁹ Laura Magazzini et al., 'Patent Disclosure and R&D Competition in Pharmaceuticals' (2009) 18 *Economics of Innovation and New Technology* 467.

³³⁰ Engineering is the application of scientific principles in a creative manner to design and develop various structures, machines, apparatus, manufacturing processes, or projects. It is a systematic process that begins with fundamental principles and culminates in the creation of a final product (see: *Engineering* (Encyclopaedia Britannica) <https://www.britannica.com/technology/engineering>). On the other hand, reverse engineering works in the opposite direction. It involves starting with a known product and meticulously working backward to uncover the underlying technical principles behind it (*Sinclair v Aquarius Electronics, Inc.* 42 Cal App 3d 216, 226, 116 Cal Rptr 654, 661 (1974); on the subject also: Ansgar Ohly, 'Reverse Engineering: Unfair Competition or Catalyst for Innovation?' in W Prinz zu Waldeck und Pyrmont, M Adelman, R Brauneis, J Drexler, and R Nack (eds), *Patents and Technological Progress in a Globalized World: Liber Amicorum Joseph Straus* (Berlin and Heidelberg 2008) 535 et seq.; on reverse engineering see also: Laura Magazzini et al., 'Patent Disclosure and R&D Competition in Pharmaceuticals' (2009) 18 *Economics of Innovation and New Technology* 467 et seq.).

³³¹ Debleena Paul et al., 'Artificial Intelligence in Drug Discovery and Development' (2021) 26(1) *Drug Discovery Today* 81.

³³² Jonathan M Stokes et al., 'A Deep Learning Approach to Antibiotic Discovery' (2020) 180 *Cell* 688.

AI seems on its way to become a “general-purpose method of invention that can reshape the nature of the innovation process”.³³³

2. The Medical Sector

a) AI in Diagnostics and Personalised Medicine

AI is making remarkable strides also in advancing innovation within the medical sector. One prominent area of impact is in diagnostics, where machine learning models are proving to be a promising technology.³³⁴ These models are utilised to analyse medical data and effectively identifying abnormalities that may evade detection by the human eye.³³⁵

They are achieving diagnostic accuracy that is comparable to, or sometimes superior to, that of human experts, across multiple clinical domains. This includes various conditions, including cancer, osteoarthritis, Parkinson’s disease and pulmonary nodules.³³⁶ AI systems, for example, have demonstrated high sensitivity in detecting lung nodules, hip fractures, coeliac disease, and early-stage cancer from imaging modalities.³³⁷ Although it is still undergoing clinical validation, Microsoft’s AI Diagnostic Orchestrator recently achieved an accuracy rate of 85% on complex case simulations from the New England Journal of Medicine, significantly outperforming general practitioners (at around 20%).³³⁸ Such results highlight the potential of AI, although real-world trials and regulatory approval are still pending.

AI is also advancing the field of personalised medicine, for example by identifying treatments based on the patient’s genetic data.³³⁹ The use of AI also plays a crucial role in personalised treatments, especially in the data-driven approach to disease diagnosis, allowing for the processing of large volumes of sensitive patient data and enabling the delivery of tailored treatment based on accurate analysis and calculations.³⁴⁰ This is particularly valuable in the

³³³ Stefano Bianchini, Moritz Müller and Pierre Pelletier, ‘Artificial Intelligence in Science: An Emerging General Method of Invention’ (2022) 51(10) *Research Policy* 104604; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 75.

³³⁴ Ivan Khoo Yi and Andrew Fang Hao Sen, ‘The Rise and Application of Artificial Intelligence in Healthcare’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence and Intellectual Property* (OUP 2021) 28; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 73.

³³⁵ Claudio Luchini, Antonio Pea and Aldo Scarpa, ‘Artificial Intelligence in Oncology: Current Applications and Future Perspectives’ (2021) 126 *Nature* 5.

³³⁶ Giovanni Morone et al., ‘Artificial Intelligence in Clinical Medicine: A State-of-the-Art Overview of Systematic Reviews with Methodological Recommendations for Improved Reporting’ (2025) 7 *Frontiers in Digital Health* 2 et seq.

³³⁷ Ibid.

³³⁸ Gordon D Schiff, ‘AI-Driven Clinical Documentation - Driving Out the Chitchat?’ (2025) 392(19) *New England Journal of Medicine* 1877 et seq.; Alice Park, ‘Microsoft’s AI Is Better Than Doctors at Diagnosing Disease’ (*Time*, 2 July 2025).

³³⁹ Nicholas J Schork, ‘Artificial Intelligence and Personalized Medicine’ (2019) 178 *Cancer treatment and research* 265.

³⁴⁰ An example is the collaboration between Tencent, a Chinese technology giant, and Medopad, a British healthcare firm. Together, they have developed AI software that reduces the time needed to diagnose Parkinson’s disease from 30 minutes to a mere 3 minutes (Rory Cellan-Jones, ‘Parkinson’s Diagnosis Set to Be Sped Up by Tencent’s AI’ (BBC News, 8 October 2018) <https://www.bbc.com/news/technology-45780755>).

context of rare diseases, where AI technology empowers doctors to provide fast and precise results in complex medical examinations like colonoscopies. Corresponding AI-based simulation mechanisms can make care management at research sites more efficient. Findings from previous studies, for example, optimized the need for drugs for particularly expensive preparations.

b) Ageing Populations and Predictive Modelling

AI is similarly being employed to support demographic and epidemiological forecasting, particularly in response to the growing pressures associated with ageing populations and the rising prevalence of chronic diseases. These challenges pose a significant threat to the sustainability of national health systems across Europe, prompting a shift toward data-driven health governance.

An example is Italy's National Health Service, which tried to develop predictive modelling systems.³⁴¹ These models integrate electronic health records, genomic data, and socioeconomic indicators to project healthcare needs and expenditure at the population level over medium- to long-term time horizons.³⁴² The initiative aims to move beyond the traditional compartmentalised healthcare model by fostering horizontal coordination across hospital, community, home, and pharmaceutical care sectors. It does so by classifying diseases, stratifying chronic conditions based on risk profiles, and simulating the allocation of medical and financial resources accordingly.³⁴³ Such integration enables real-time forecasting of disease prevalence, healthcare demands, and associated costs, supporting more efficient and equitable planning of services. However, no recent reports have emerged, so it is likely that the initiative has slowed considerably. Still, the idea of using AI to model population health needs and forecast resource allocation remains a compelling approach for improving the efficiency, equity, and sustainability of healthcare systems facing demographic and epidemiological pressures.

Furthermore, the implementation of AI technologies within this context also necessitates the development of health workforce competencies in digital health. A recent European Union initiative, the "Susa" project, is addressing this requirement by training over 6,500 healthcare professionals, including physicians and nurses, on the ethical, regulatory, and operational aspects of AI in clinical care.³⁴⁴ The project provides a shared curriculum across multiple medical institutions, fostering consistent knowledge transfer and upskilling across jurisdictions.

³⁴¹ Roberto Reale et al., 'The Design and Implementation of a National AI Platform for Public Healthcare in Italy: Implications for Semantics and Interoperability' (24 April 2023) *arXiv* 1 et seq.

³⁴² Ministero della Salute, 'Dettagli degli Investimenti nel PNRR Salute' (2024) <https://www.pnrr.salute.gov.it/portale/pnrrsalute/dettaglioContenutiPNRRSalute.jsp?lingua=italiano&id=5809&area=PNRR-Salute&menu=investimenti&tab=2>.

³⁴³ Quotidiano Sanità, 'PNRR: Investimenti e Riforme per il Settore dell'Istruzione' (2023) <https://www.quotidianosanita.it/allegati/allegato4720984.pdf>.

³⁴⁴ For more information see: <https://www oulu.fi/en/projects/sustainable-healthcare-digital-health-data-competence>; Clive Cookson, 'EU Project Launched to Prepare Health Workers for a Digital Future' (*Financial Times*, 5 March 2025) <https://www.ft.com/content/a56ef5a3-f5d8-446d-ae9b-f503cce20de7>; University of Oulu, 'SUSA: Developing Sustainable Healthcare across Europe' (*Healthcare in Europe*, 10 January 2025) <https://www.healthcare-in-europe.com/en/news/susa-developing-sustainable-healthcare-across-europe.html>.

3. Preliminary Results

Preliminary findings suggest that the pharmaceutical and medical sectors offer the most potential for AI-generated inventions. In the pharmaceutical industry, for example, AI is being used throughout the drug development process, from identifying targets and screening molecules to optimising clinical trials and repurposing drugs. The aim of these applications is to mitigate the high costs, long timelines and low success rates that are typical of traditional pharmaceutical research and development. Case studies such as the discovery of *Halicin* and AI-assisted cancer drug development demonstrate AI's capacity to uncover novel compounds and enhance trial efficiency. AI is being increasingly integrated into industry, with major pharmaceutical firms investing in AI partnerships or in-house capabilities, often supported by patent strategies that protect their innovations and enable returns on investment.

In the medical sector, AI is having a significant impact on diagnostics and personalised medicine. Machine learning models have demonstrated diagnostic accuracy comparable to, or even superior to, that of medical professionals in specialisms such as oncology, neurology, and radiology. Furthermore, AI supports predictive modelling in public health, particularly in managing the challenges posed by ageing populations and chronic diseases.

As AI becomes increasingly integrated into research and clinical applications, the evolving landscape of AI-related inventions requires a critical reappraisal of the patentability framework. To accommodate these inventions, a proactive and adaptive approach to patent law is essential, ensuring that the legal system remains responsive to the rapid pace of technological development.

C. THE INTERCONNECTION BETWEEN AI AND PATENT LAW

I. The Rationale Behind Patent Protection

1. Examining Patent Incentives

The purposes underlying the grant of exclusive rights to inventions were already evident in the reasoning advanced by advocates of patent law during the 18th and 19th centuries.³⁴⁵ *Machlup* and *Penrose* structured these early rationales into four distinct theoretical frameworks.³⁴⁶ Despite their roots in the historical evolution of patent law, these frameworks continue to be recognised as functional theories.³⁴⁷ These are the natural rights theory, the reward theory, the incentive theory, and the disclosure theory.³⁴⁸ These theories and their applicability to AI will be discussed in the following subchapters.

Generally speaking, the principal aim of patent law is to balance the interests of the inventor and the public while promoting technological development and contributing to the broader public good.³⁴⁹ The investor needs protection in form of an exclusive right to gain profits for the time and resources invested in the development, whilst the public profits from the technical progress.³⁵⁰ This transparency also reduces the likelihood of parallel developments and fosters more efficient innovation.³⁵¹ *Ex ante*, prior to the issuance of a patent, the potential to obtain exclusive rights serves to encourage investment in research and development by securing the inventor's capacity to recoup costs and obtain a return through monopolistic commercialisation.³⁵² Since patents are publicly disclosed, they serve as a valuable source of technical information, allowing researchers to assess the state of the art and avoid duplicative efforts.³⁵³ This disclosure, mandated amongst others by Articles 83 and 93 EPC, serves as a reciprocal exchange: inventors are granted temporary exclusivity in return for making technical

³⁴⁵ Alfred Heggen, *Erfindungsschutz und Industrialisierung in Preußen* (GESIS 2008) 69 et seq.; Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 190.

³⁴⁶ Fritz Machlup and Edith Penrose, 'The Patent Controversy in the Nineteenth Century' (1950) 10(1) *J Economic History*, 10 et seq.

³⁴⁷ See for example Heribert Burghartz, *Technische Standards, Patente und Wettbewerb* (Duncker & Humblot, Berlin 2011) 63.

³⁴⁸ The terminology is not consistent, either in the works of *Machlup* and *Penrose* or in contemporary literature. (See for example Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 262).

³⁴⁹ Herbert Zech, 'Brauchen wir ein Patentrecht?' in H Zech et al. (eds), *Patentschutz: Impulsgeber für Innovationen oder Behinderung von Produktion?* (2021) *ifo Schnelldienst* 3; Martin Stierle and Laura Valtere, 'Addressing the Gene Therapy Bottleneck in the EU: Patent vs Regulatory Incentives' (2025) *GRUR International* 406.

³⁵⁰ Mark A Lemley and Dan L Burk, 'Policy Levers in Patent Law', 89 *Virginia Law Review* (2003) 1576.

³⁵¹ Stuart J H Graham and Deepak Hegde, 'Do Inventors Value Secrecy in Patenting? Evidence from the American Inventors Protection Act of 1999' (2015) 61 *Management Science*, 1190, 1200 et seq.

³⁵² Stefan Wagner, 'Patente – das schlechteste Anreizsystem für Innovationen, abgesehen von allen anderen?', in Herbert Zech et al. (eds), *Patentschutz: Impulsgeber für Innovationen oder Behinderung von Produktion?* (2021) *ifo Schnelldienst* 6.

³⁵³ *Ibid*; see also for a general discussion on the importance of disclosure: Travis A Dyer et al., 'The Effect of Patent Disclosure Quality on Innovation' (2024) 77(2-3) *Journal of Accounting and Economics* 101647 <https://www.sciencedirect.com/science/article/pii/S016541012300071X>; Sonja Lück et al., 'Early Disclosure of Invention and Reduced Duplication: An Empirical Test' (2020) 66(6) *Management Science* 2677–2685 <https://doi.org/10.1287/mnsc.2019.3521>.

knowledge publicly accessible. Through publication, competitors gain insight into existing developments, which supports further research and facilitates incremental innovation.

Beyond the pre-grant phase, the patent framework is also understood to serve *ex post* incentives. While the invention stage often incurs substantial initial costs, bringing an invention to market as a viable innovation generally demands even greater financial and technical investment. Patent protection helps secure the necessary confidence for undertaking these additional steps, as it grants the holder exclusive control over the resulting commercial applications, commonly referred to as the incentive to innovate or the innovation function.

Patents function as a mechanism through which inventors can recover costs incurred in research and development by granting them a time-limited monopoly (typically 20 years).³⁵⁴ This prevents others from manufacturing, selling, or importing their inventions.³⁵⁵ The exclusive right to use the patented invention allows the inventor to offer products at a price or condition that enables reimbursement of previous investments and, eventually, profit generation.³⁵⁶ This exclusivity creates dynamic incentives for investments in emerging technologies.³⁵⁷ While a patent per se does not guarantee profit and success, it increases the chances since there is no direct competition.³⁵⁸ Patent protection is often essential for enabling licensing negotiations, as it provides a legally enforceable right that reduces the risks associated with disclosing proprietary information.³⁵⁹ In contrast, non-disclosure agreements, while useful, offer limited security and are difficult to enforce, especially across jurisdictions. Without patent rights, potential licensees are unlikely to engage, as they require legal certainty about the licensor's entitlement to the subject matter.³⁶⁰ However, the product still needs to be in demand and have a market; otherwise, a patent cannot ensure profits.³⁶¹

The extent to which patent rights incentivise innovation varies across different fields.³⁶² Empirical evidence suggests that in the manufacturing industry, most products would have been developed even if companies had known they would not be eligible for patents.³⁶³ Conversely, executives in the pharmaceutical industry have indicated that without patent protection, 60% of

³⁵⁴ Article 63(1) EPC; In exceptional cases, the term of a patent may be extended pursuant to Article 63(2) and (4) EPC.

³⁵⁵ Lionel Bently et al., *Intellectual Property Law* (5th edn, OUP 2018) 393; Edmund W Kitch, 'Elementary and Persistent Errors in the Economic Analysis of Intellectual Property' 53 *Vanderbilt Law Review* (2000) 1729 et seq.

³⁵⁶ Suzanne Scotchmer, *Innovation and Incentives* (MIT Press 2004) 40.

³⁵⁷ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1457.

³⁵⁸ Stephen Yelderman, 'Do Patent Challenges Increase Competition?' (2016) 83(4) *University of Chicago Law Review* 1943 et seq.; for more of the economic impact see for example: Robert P Merges, 'The Economic Impact of Intellectual Property Rights: An Overview and Guide' (1995) 19(2) *Journal of Cultural Economics* 103 et seq.

³⁵⁹ David J Teece, 'Profiting from Technological Innovation' (1986) 15(6) *Research Policy* 287-289.

³⁶⁰ Ansgar Ohly, 'Wie weit reicht der Patentschutz an Universitäten?' (Forschung & Lehre, 31 January 2022) <https://www.forschung-und-lehre.de/recht/wie-weit-reicht-der-patentschutz-an-universitaeten-4389>.

³⁶¹ Martin Eifert and Wolfgang Hoffmann-Riem, *Geistiges Eigentum und Innovation: Bestandsaufnahme und Perspektiven* (Baden-Baden 2004) 26.

³⁶² Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 20.

³⁶³ Richard D Nelson and Roberto Mazzoleni, 'Economic Theories About the Cost and Benefits of Patents' in National Research Council (US), *Intellectual Property Rights and the Dissemination of Research Tools in Molecular Biology: Summary of a Workshop Held at the National Academy of Sciences, February 15–16, 1996* (National Academies Press, 1997) 17-20.

new pharmaceuticals would not have been developed.³⁶⁴ This suggests that patent monopolies are likely crucial for stimulating research and development in the pharmaceutical sector.³⁶⁵

Not all inventions require patent protection. For example, in sectors with very short product life cycles, new generations of products may reach the market before a patent is granted. This could potentially be the case for some AI technologies. Additionally, the 20-year patent term aims to balance innovation incentives with public access, though some argue this period should vary by industry based on development timelines and costs. These matters and possible solutions thereto will be discussed more in depth in Part G.

The advent of AI-related inventions introduces a paradigm shift in the understanding of patents. Over time, there exists a vast but generally undisclosed reservoir of inventions that are theoretically attainable, given the advancement of humanity's knowledge and technological capabilities, a concept often referred to as the "inevitability of inventions", with roots traced back to *Ogburn/Thomas*³⁶⁶ and *Ihde*.³⁶⁷ Historically, the flow of patent applications from this concealed reservoir has been influenced by a combination of contemporary socio-economic factors, the breadth of human ingenuity, and the resources allocated to invention discovery. The inclusion of AI systems in the arsenal for unearthing potential inventions is poised to substantially relax the latter two constraints. Human ingenuity will no longer be an indispensable factor, and the costs associated with exploration may diminish to the point of relative insignificance.³⁶⁸

2. Theories of Patent Protection Applied to AI

While patents play a crucial role in incentivising innovation and fostering technological progress, their effectiveness can vary across different sectors and technologies. The patent system continues to evolve to address the challenges of rapidly advancing fields like AI.

The most common theories to justify the patent system are the natural rights theory, the reward theory, the incentive theory, and the disclosure theory. In addition to conventional theories, legal scholars and practitioners have advanced alternative conceptual approaches to the patent system, including the utilitarian theory and the public trust theory.³⁶⁹ The utilitarian perspective maintains that the grant of a monopoly is not an end in itself but a means to promote innovation and economic development for the benefit of society.³⁷⁰ This view is notably articulated by

³⁶⁴ Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 20.

³⁶⁵ *Ibid*.

³⁶⁶ William F Ogburn and Dorothy Thomas, 'Are Inventions Inevitable? A Note on Social Evolution' (1922) 37 *Political Science Quarterly* 83.

³⁶⁷ Aaron J Ihde, 'The Inevitability of Scientific Discovery' (1948) 67(6) *Scientific Monthly* 427 et seq.

³⁶⁸ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1462.

³⁶⁹ For more on the utilitarian approach to justify patents see: Emir A C Mohammed, 'The Utilitarian Fruits Approach to Justifying Patentable Subject Matter' (2011) 10 *John Marshall Review of Intellectual Property Law* 753 et seq.

³⁷⁰ On how patents serve as incentives to stimulate innovation and economic growth, see: Alan J Devlin and Neel U Sukhatme, 'Self-Realizing Inventions and the Utilitarian Foundation of Patent Law' (2009) 51 *William & Mary L Rev* 897, 901-905; for a more critical view, highlighting potential shortcomings in the argument that patents

economists such as *Machlup* and *Penrose*, who argue that the patent system is justified insofar as it contributes to overall social welfare through technological progress.³⁷¹ In contrast, the public trust theory suggests that patents are granted not solely for private enrichment but as part of a broader fiduciary arrangement in which the state entrusts inventors with rights that are to be exercised in the public interest.³⁷² According to this view, patentees bear a normative obligation to deploy their inventions for the collective good, rather than purely for individual financial gain.³⁷³

These theories originate from an era predating the existence of AI and, as such, should not be construed as intentionally prohibitive with respect to novel technologies.³⁷⁴ While there are some exceptions, patent law generally does not distinguish between different technologies in the definition and application of protection requirements.³⁷⁵ Therefore, the theories and criteria for interpretation have been framed to be generally valid. Still, as will be later discussed, a common thread running through these theories is their anthropocentrism, where patent protection is awarded to humans.³⁷⁶

Still, one of the problems of applying theories of patent protection to 21st century technology is that mechanics has historically been the paradigmatic field of invention, whereas now the emergence of other sectors has resulted in the demand for patent protection for inventions in these new areas as well.³⁷⁷ Legislative response extended the rules for mechanical inventions to other sectors as well. Even today, inventions made “in all fields of technology” can receive patent protection. However, applying the same rules originally intended for mechanical engineering to other sectors has led to different and new problems specific to each sector.³⁷⁸ Many of the critical issues have arisen because technological innovation is moving at a much faster rate than the ability (and willingness) of the patent system to adapt to it.³⁷⁹ While applying general rules to these areas is difficult, creating a special discipline specific to each sector and each type of invention is complex due to the novelty of the phenomenon to be regulated and the risk of creating excessive fragmentation of the system.³⁸⁰

necessarily lead to increased innovation, see: Sigrid Sterckx, ‘A Critique of the Utilitarian Argument for the Patent System’ (2004) 11 *Philosophy in the Contemporary World* 81, 81-88.

³⁷¹ Fritz Machlup and Edith Penrose, ‘The Patent Controversy in the Nineteenth Century’ (1950) 10(1) *J Economic History*, 10 et seq.

³⁷² Peter Drahos, *A Philosophy of Intellectual Property* (Ashgate 1996) 231 et seq.

³⁷³ *Ibid.*

³⁷⁴ For a “dynamic interpretation” of American intellectual property law in the AI context *de lege lata* see: Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1112.

³⁷⁵ Dan L Burk and Mark A Lemley, ‘Is Patent Law Technology-Specific?’ 17(4) *Berkeley Technology Law Journal* (2002) 1155.

³⁷⁶ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 6.

³⁷⁷ Steve Hickman, ‘Reinventing Invention: Why Changing How We Invent Will Change What We Patent and What to Do About It’ (2009) 91(2) *Journal of the Patent and Trademark Office Society* 110.

³⁷⁸ Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 383.

³⁷⁹ *Ibid.*

³⁸⁰ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 152 et seq https://iris.unipv.it/retrieve/e1f104fd-5b69-8c6e-e053-1005fe0aa0dd/Tesi%20di%20dottorato_Daniele%20Cerulla.pdf.

Therefore, finding a justification in common patent law theories to accommodate AI-related inventions seems necessary. Simultaneously, it is essential to distinguish between the potential and desirability of extending patent protection.³⁸¹ Considerations regarding whether the existing patent framework should, from a policy standpoint, extend protection to AI-related inventions merge with a legal analysis, grounded in the current state of the law, to discern the viability of such an approach.³⁸²

a) The Reward-by-Monopoly Theory

aa) General Remarks

One of the justifications for patent protection is offered by the reward theory. The reward-by-monopoly theory frames patent protection as a means of compensating the inventor for their contribution to society. This reward, understood as the “recognition of a particular achievement”,³⁸³ is granted in the form of a state-conferred, time-limited right of exclusion.³⁸⁴

This theory holds that inventors should receive fair compensation for the societal value of their contributions, justified by considerations of justice and reflecting the expenses and efforts involved.³⁸⁵ The patent system aims to deliver this compensation by granting exclusive rights. This theory justifies the patent system as a mechanism for rewarding inventors with a temporary exclusive right, recognising their ingenuity and the resources invested in developing novel and useful inventions. It underscores the post-invention dimension by focusing on the allocation of monopoly profits as compensation, thereby enabling inventors to recoup their investments. The broader societal benefit arises indirectly, through the stimulation of further innovation and technological progress.³⁸⁶

This rationale can already be found in the work of *Smith*.³⁸⁷ Even proponents of utilitarianism, such as *Mill*, supported the equitable nature of such a reward. In present-day legal doctrine and case law, the reward-based justification is frequently cited, often alongside other theoretical models.³⁸⁸

Nonetheless, a thorough explanation of why the reward theory should underpin contemporary patent law is generally lacking; its relevance is instead commonly treated as a self-evident premise.

³⁸¹ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 11.

³⁸² Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 11.

³⁸³ BGH, Judgment of 17 February 1987, X ZR 32/86 *Tollwutvirus* [1987] GRUR 231, 232.

³⁸⁴ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 405.

³⁸⁵ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 195.

³⁸⁶ Michael A Klein, ‘The Reward and Contract Theories of Patents in a Model of Endogenous Growth’ (2022) 147 *European Economic Review* 104178; Vincenzo Denicolò and Luigi A Franzoni, ‘The Contract Theory of Patents’ (2003) 23 *International Review of Law & Economics* 365-380.

³⁸⁷ Adam Smith, *Wealth of Nations*, W Strahan and T Cadell (eds.) (London 1776) 754.

³⁸⁸ John S Mill, *Principles of Political Economy* (1870) V.10.25.

bb) The Reward-by-Monopoly Theory Applied to AI-Related Inventions

Initially, this theory seems to remain neutral in relation to new technologies since the core rationale behind the patent system is to foster innovation.³⁸⁹ While it requires sufficient human engagement for the allocation of patent rights, it does not inherently or conversely prohibit the granting of such rights for inventions generated without it.³⁹⁰

Still, three factors need to be considered when applying this theory to AI-related inventions.

The applicability of the reward-by-monopoly theory to inventions generated by AI systems is increasingly contested, given that such systems lack the capacity for consciousness, intention, or the moral agency presupposed by deontological frameworks. This theory, which conceptualises patent protection as a form of moral entitlement, frames the grant of exclusive rights as a retrospective reward for human ingenuity and intellectual labour.³⁹¹ As such, it presumes a deserving human subject whose creative contribution justifies proprietary control over the invention.³⁹² The emergence of autonomous AI systems challenges this foundational assumption, prompting questions about whether deontological justifications retain normative force in the AI domain.³⁹³ Indeed, the growing autonomy of inventive AI tools corresponds with a diminished relevance of moral-reward-based theories, particularly in cases where the inventive step arises within the so-called “black box” phase, an opaque computational process devoid of human interpretability or input (discussed more in depth in Section F.I.2.b). Nevertheless, at this point, it would be premature to dismiss human involvement altogether in AI-related inventions. While the creative core of the invention may originate from autonomous computation, human actors often still at some level engage in the formulation of input parameters, the curation and validation of outputs, and the strategic selection of viable solutions.³⁹⁴ These forms of human intervention may involve significant intellectual effort and creative judgment, suggesting that the rewarding phase of AI innovation should be limited to stages involving demonstrable human contribution.³⁹⁵ Accordingly, a refined application of the reward-by-monopoly theory might shift focus from the internal, autonomous operations of AI systems to the human activities surrounding them, thereby preserving a normative basis for patent protection grounded in merit and fairness.

Secondly, the reward-by-monopoly theory primarily considers the inventor or patent holder. It is important to note that the majority of patents today are held by corporate or institutional

³⁸⁹ Kenneth Arrow, ‘Economic Welfare and the Allocation of Resources for Invention’ in *The Rate and Direction of Inventive Activity: Economic and Social Factors* (Princeton University Press 1962) 609-626 passim.

³⁹⁰ Fritz Machlup, ‘Die wirtschaftlichen Grundlagen des Patentrechts - 1. Teil’ (1961) *GRUR Ausland* 373.

³⁹¹ William W Fisher, ‘Theories of Intellectual Property’ in S Munzer (ed), *New Essays in the Legal and Political Theory of Property* (Cambridge University Press 2001) 169-170.

³⁹² Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 39-41.

³⁹³ Matthew Rimmer, ‘The Artificial Inventor and the Future of Patent Law’ (2021) *IIC* 5-6.

³⁹⁴ Ana Ramalho, ‘Patentability of AI-Generated Inventions: Is a Reform of the Patent System Needed?’ (2021) 52(4) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 4.

³⁹⁵ WIPO, *Summary of Second and Third Sessions* (WIPO/IP/AI/3/GE/20/INF/5, 8 January 2021) https://www.wipo.int/edocs/mdocs/mdocs/en/wipo_ip_ai_3_ge_20/wipo_ip_ai_3_ge_20_inf_5.pdf 5.

entities, rather than individual inventors, primarily encompassing corporations, academic institutions, and government entities that employ or financially support human researchers in their innovative endeavours. Reward rationale has thus long been superseded by market dynamics predominantly influenced by industries rather than individuals. Protection frameworks, if ever deemed necessary, will need to shift their focus from inventors to investors. Still, the human contribution to the research and development process should not be overlooked.

Lastly, the reward-by-monopoly theory focuses on the immediate reward for a specific invention. Companies may hesitate to invest in AI technologies without sufficient assurance regarding the patentability of their research outcomes. Rewards for inventors depend on the availability thereof for inventions generated by inventive technologies: considering the enormous costs that developing such high-end computers would entail, a monopoly over “just” the inventive computer would not repay the investment or be a satisfactory reward.³⁹⁶ If, instead, a developer or investor knows that the outcome of an inventive machine is a patentable subject matter, investments in the development of AI technologies would be justified. Conversely, permitting the patentability of *every* invention originating from AI could lead to a disproportionate reward, potentially surpassing the original impetus for innovation (see Section G.I.3).³⁹⁷

Therefore, this theoretical framework does not provide any definitive guidance for or against granting protection for AI-related inventions.³⁹⁸ While the AI itself cannot be the recipient of a reward, its owner or lawful user may benefit from the granted rights.³⁹⁹ Moreover, the concept of reward does not necessarily require a correlation with the actual effort invested in the development of the invention.⁴⁰⁰ An invention resulting from decades of research does not receive a better reward (for example, through extended protection) than one that emerges largely by chance.⁴⁰¹ For this reason, it has been argued that the reward is, in individual cases, unfair and therefore no longer serves as a convincing justification for the patent system.⁴⁰²

In summary, although the reward-by-monopoly theory is still fundamental to patent law, applying it to AI-related inventions highlights major theoretical and practical limitations. The theory’s reliance on human moral desert is increasingly tenuous in contexts where human intellectual input is minimal or absent, calling into question the continued normative force of

³⁹⁶ For a comprehensive discussion see: Justine Pila, *The Requirement for an Invention in Patent Law* (OUP 2010) 174 et seq.; Roberto Mazzoleni and Richard R Nelson, ‘The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate’ (1998) 27(3) *Research Policy* 273 https://www.yildizoglu.fr/moddyn2/articles/mazzol_nelson_patent.pdf (stating that the holding of a patent at an early stage provides assurance that, if development is technologically successful, its economic rewards can be appropriated).

³⁹⁷ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1458.

³⁹⁸ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 405.

³⁹⁹ Sven Hetmank and Anne Lauber-Rönsberg, ‘Künstliche Intelligenz - Herausforderungen für das Immaterialgüterrecht’ (2018) *GRUR* 576.

⁴⁰⁰ Fritz Machlup, ‘Die wirtschaftlichen Grundlagen des Patentrechts - 1. Teil’ (1961) *GRUR Ausland* 382.

⁴⁰¹ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 405.

⁴⁰² Joseph Straus and Rainer Moufang, *Hinterlegung und Freigabe von biologischem Material für Patentierungszwecke: Patent- und eigentumsrechtliche Aspekte* (Baden-Baden 1989) 36 et seq.; Niclas Kunczik, ‘Die Legitimation des Patentsystems im Lichte biotechnologischer Erfindungen’ (2003) *GRUR* 848.

deontological justifications. Furthermore, the shift in patent ownership from individuals to institutions or investors complicates the rationale for rewarding inventors, highlighting the need to recalibrate the focus from personal inventiveness to broader investment incentives. Nevertheless, the economic realities of AI research and development necessitate some form of protection to encourage technological advancement, even when human contribution is limited to peripheral stages. Ultimately, the reward-by-monopoly theory neither clearly supports nor outright rejects the patentability of AI-related inventions. Instead, it suggests the need for a refined approach that limits reward to identifiable human contributions, while also acknowledging the evolving dynamics of innovation in the age of autonomous systems.

b) The Natural Rights Theory

aa) Historical Context, Challenges and Criticisms

The natural rights theory is based on various philosophical traditions of which a central component is *Locke's* labour theory of property.⁴⁰³ According to this theory, every individual holds a natural and inalienable property right to the fruits of their labour, as the labourer has mixed their own work with elements of nature.⁴⁰⁴ Although *Locke* originally developed his theory in relation to tangible goods, proponents of the natural rights theory of property later extended its application to intellectual achievements.⁴⁰⁵ Accordingly, the right to an invention is viewed as an expression of a fundamental human right. The grant of a patent by the state does not, in this view, create an exclusive right but merely affirms a right that exists independently of positive law. However, *Locke* also stipulated that “there should be enough and as good left in common for others”, suggesting limits to these rights.⁴⁰⁶

The natural rights theory faces several challenges in the context of patent law including that it struggles to explain the need for a patent application process, it does not fully justify the limited timeframe of patent protection, fails to address the collaborative nature of many modern inventions and does not account for the role of prior knowledge and societal contributions to

⁴⁰³ Christine Godt, *Eigentum an Information* (Tübingen 2007) 517 et seq.; Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 191.

⁴⁰⁴ Labor theory is usually credited to John Locke, who wrote in his *Second Treatise on Government* that “every man has a ‘property’ in his own ‘person’. This nobody has any right to but himself. The ‘labour’ of his body and the ‘work’ of his own hands, may be said, are properly his” (John Locke, *The Second Treatise on Civil Government* (Prometheus Books 1986)); see also: M J Fisher, ‘Classical Economics and Philosophy of the Patent System’ (2005) 1 *Intellectual Property Quarterly*, 26).

⁴⁰⁵ John Locke, *Two Treatises of Government* (Cambridge University Press 1988) Second Treatise, II; see also: Ofer Tur-Sinai, ‘Beyond Incentives: Expanding the Theoretical Framework for Patent Law Analysis’ (2010) *Akron Law Review* 257 et seq.

⁴⁰⁶ John Locke, *Two Treatises of Government* (Cambridge University Press 1988) Second Treatise, II: Sec. 27; see also: Jeremy Waldron, ‘Enough and as Good Left for Others’ (1979) 29 *Philosophical Quarterly* 319; Giovanni B Ramello, ‘Private Appropriability and Sharing of Knowledge: Convergence or Contradiction? The Opposite Tragedy of the Creative Commons’ in Lynn Takeyama et al. (eds), *Developments in the Economics of Copyright. Research and Analysis* (Edward Elgar 2005) 134-135; Robert P Merges, *Justifying Intellectual Property* (Harvard University Press 2011) 32-33.

inventions.⁴⁰⁷ Critics generally argue that the theory oversimplifies the inventive process.⁴⁰⁸ In his widely noted 1926 commentary on the Patent Act, *Isay* concluded that the natural rights theory of property had, for a long time, been regarded as inadequate and outdated in modern patent law.⁴⁰⁹

Despite these criticisms, elements of the natural rights theory continue to influence patent law, in particular since the turn of the 21st century.⁴¹⁰ A new interpretation of this deontological approach is offered by *Merges*.⁴¹¹ Drawing on Locke's labour theory, *Merges* develops a contemporary deontological justification for intellectual property. As in the 18th and 19th centuries, he employs the labour theory to justify property rights generally and extends its application to intellectual property.⁴¹² Intellectual property, he argues, is essential for individuals to attain control over objects, thereby enabling full freedom or autonomy.⁴¹³ Individuals in the original position would regard such freedom and autonomy as essential and would therefore recognise intellectual property rights as 'basic rights'.⁴¹⁴

Still, for a natural rights theory of property to have *de lege lata* significance, it must be reflected in the current structure of patent law.⁴¹⁵ While principles such as inventorship and the right to be named as inventor are often cited in support of this theory, they can also be justified through incentive-based reasoning.⁴¹⁶ A closer analysis of patent law reveals several inconsistencies with a natural rights foundation.⁴¹⁷ First, the strict patentability requirements and unequal treatment of second inventors and independent creators contradict a natural property right.⁴¹⁸ Second, the need to pay patent fees undermines the notion of an inherent entitlement.⁴¹⁹ Third, the legal transfer of rights in employee inventions challenges the idea of a fundamental inventor's right.⁴²⁰ Fourth, the time-limited nature of patent protection and the possibility of

⁴⁰⁷ Christoph Ann, 'Die idealistische Wurzel des Schutzes geistiger Leistungen' (2004) *GRUR International* 597 et seq.; Ralf Uhrich, *Stoffschutz* (Tübingen 2010) 100.

⁴⁰⁸ While creativity is nowadays typically associated with copyright, in the 19th century, the term creativity was used across different areas of law that granted intellectual property rights, including patent law (Brad Sherman and Lionel Bently, *The Making of Modern Intellectual Property Law* (Cambridge University Press 1999) 44; Eva Stanková, 'Human Inventorship in European Patent Law' (2021) 80 *The Cambridge Law Journal* 21).

⁴⁰⁹ Rudolf Isay, *Patentgesetz und Gesetz, betreffend den Schutz von Gebrauchsmustern* (4th ed., Berlin 1926) 22.

⁴¹⁰ For example, the German Federal Constitutional Court ultimately bases the protection of patent rights under Article 14 of the Basic Law on a justification at least analogous to Locke's theory (for further details see: Tobias Timmann, *Das Patentrecht im Lichte von Art. 14 GG*, Mohr Siebeck (2008), 85; also: Martin Stierle, 'A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System' (2021) *GRUR International* 120).

⁴¹¹ See Robert P Merges, *Justifying Intellectual Property* (Harvard University Press 2011) 40 et seq., still it is unclear whether Merges himself considers his theory to fall within the realm of natural law. On this point, he emphasises that considerations of efficiency still hold relevance at an intermediate level of argumentation, although efficiency does not constitute a foundational principle within his framework (see also: Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 193).

⁴¹² Robert P Merges, *Justifying Intellectual Property* (Harvard University Press 2011) 72 et seq.

⁴¹³ *Ibid.*

⁴¹⁴ *Ibid.*, 112.

⁴¹⁵ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 194.

⁴¹⁶ Christoph Ann, 'Die idealistische Wurzel des Schutzes geistiger Leistungen' (2004) *GRUR International* 601.

⁴¹⁷ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 194.

⁴¹⁸ Christoph Ann, 'Die idealistische Wurzel des Schutzes geistiger Leistungen' (2004) *GRUR International* 602.

⁴¹⁹ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 195.

⁴²⁰ Carsten Bauer, *Patente für Pflanzen - Motor des Fortschritts?* (Baden-Baden 2020) 110 et seq.; Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 195.

compulsory licensing suggest that public interest is prioritised over a supposed natural right.⁴²¹ Although these points do not entirely exclude natural rights theory from patent discourse, they demonstrate that current patent law is not based on such a foundation.⁴²²

bb) The Natural Rights Theory Applied to AI and AI-Related Inventions

In the context of developing an AI system, the significant work undertaken by AI professionals, including programmers, data providers, trainers, and data scientists, could warrant the granting of patent rights under the natural rights theory. The AI programmer designs algorithms that serve as the foundational components of the AI. The data provider supplies the necessary data for the AI system to learn from, while the trainer guides and corrects the AI during its learning process.

The patenting of AI-related inventions raises concerns about potential negative impacts on human intelligence and scientific methods. It could potentially allow less skilled people with fewer resources to gain access to the process of invention, disrupting traditional innovation paradigms. However, it's important to recognize that automation and technological advancement have been displacing certain types of jobs long before the advent of AI. The rapid increase in computer performance, as described by *Moore's law*,⁴²³ has been accelerating the pace of industrialization long before the advent of AI, leading to the displacement of workers performing routine, repetitive tasks.⁴²⁴ Already in the 1930s, *Keynes* clearly identified the problems arising from the advent of increasingly advanced technologies, using the evocative definition of "technological unemployment".⁴²⁵ The reality is that in the future some jobs will be less in demand and others will be created.⁴²⁶ The challenge will be to manage the skill shift and update skills to focus on more value-added tasks.⁴²⁷ AI is not a replacement for humans; it is a replacement for some tasks previously performed by humans.

⁴²¹ Christoph Ann, 'Die idealistische Wurzel des Schutzes geistiger Leistungen' (2004) *GRUR International* 602; Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 195.

⁴²² Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 195.

⁴²³ See (n 175).

⁴²⁴ Alison DeNisco Rayome, 'Demand for AI Talent Exploding: Here Are the 10 Most In-Demand Jobs' (1 March 2018, TechRepublic) <https://www.techrepublic.com/article/demand-for-ai-talent-exploding-here-are-the-10-most-in-demand-jobs/>.

⁴²⁵ John Maynard Keynes, 'Economic Possibilities for our Grandchildren' (1930), reprinted in *Essays in Persuasion* (Macmillan 1931) 364.

⁴²⁶ For a general discussion see: Carl B Frey and Michael Osborne, *The Future of Employment: How Susceptible are Jobs to Computerisation?* (OUP 2013); James Vincent, 'Automation Threatens 800 Million Jobs, But Technology Could Still Save Us, Says Report' (The Verge, 30 November 2017) <https://www.theverge.com/2017/11/30/16719092/automation-robots-jobs-global-800-million-forecast>.

⁴²⁷ Manuela Gianni, 'McKinsey Stima il Ritorno degli Investimenti in AI: "Potenziale Raddoppio del Cash Flow Entro il 2030"' (Digital4Executive, 19 November 2018) <https://www.digital4.biz/executive/digital-transformation/mckinsey-intelligenza-artificiale-ritorno-investimenti/>; James Manyika et al., 'Jobs Lost, Jobs Gained: What the Future of Work Will Mean For Jobs, Skills, and Wages' (McKinsey, November 2017) <https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages>; Luciano Floridi, *The Fourth Revolution: How the Infosphere is Reshaping Human Reality* (OUP 2014) 129.

From a deontological standpoint, although in a human centric patent system, the patenting of AI-related inventions does not raise doubts,⁴²⁸ as long as a substantial “human link” exists, labour is undertaken and personal expression is manifested.⁴²⁹ Thus a natural ownership claim or a claim similar to ownership should be granted to the creator of something, meaning that the inventor is entitled to an exclusionary right in the form of a patent.⁴³⁰ However, the analogy to ownership of physical objects is problematic, regardless of whether natural law exists at all.⁴³¹ There are fundamental differences between rights in intangible creations and ownership of tangible objects, particularly concerning the subject matter and duration.⁴³² Applying this to AI-related inventions, such inventions cannot be granted protection because the AI itself cannot hold a natural claim to its results.⁴³³ Nevertheless, this does not exclude the possibility that the owner or lawful user of the AI may possess such a claim.⁴³⁴

Still, the increasing autonomy of AI systems complicates the application of this theory. The application of this theory to AI-related inventions fundamentally converges at the dimension of human participation. When AI functions as a tool under human supervision, similar to an inventor using a microscope, the validation of patent theories encounters no significant hurdles. Still, when the degree of human involvement in an inventive process falls below a certain critical threshold, such that human agency is no longer meaningfully implicated, the justificatory basis of the natural rights theory becomes problematic.⁴³⁵ AI-related inventions may lack the intentionality and personal investment traditionally required for a moral claim to arise.⁴³⁶ As such, the more independent the AI system becomes, the less tenable a deontological justification for patent rights appears.⁴³⁷ This raises a fundamental question: can patent protection justifiably extend to intangible assets generated not by a human agent but by an autonomous system? One potential response is the notion of “attribution perpetuation”, which proposes that the creative personality or labour of the original programmer or designer may be

⁴²⁸ Emir A Mohammed, ‘What is an Invention? A Review of the Literature on Patentable Subject Matter’ (2008) 15(2) *Richmond Journal of Law and Technology*.

⁴²⁹ Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 69 et seq.

⁴³⁰ Fritz Machlup, ‘Die wirtschaftlichen Grundlagen des Patentrechts - 1. Teil’ (1961) *GRUR Ausland* 377.

⁴³¹ Bernd Rüthers, Christian Fischer and Axel Birk, *Rechtstheorie: mit juristischer Methodenlehre* (Munich 2018) 412 et seq.

⁴³² Wolfgang Bernhardt, *Die Bedeutung des Patentschutzes in der Industriegesellschaft* (C Heymann 1974) 8 et seq.

⁴³³ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 405.

⁴³⁴ *Ibid.*

⁴³⁵ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, ‘Intellectual Property Justification for Artificial Intelligence’ (MPI Research Paper No. 20-02, 24 February 2020) 10.

⁴³⁶ The relationship between inventorship and autonomy in AI systems is unclear, as there is no binding definition of inventorship from the BoA, though courts in different jurisdictions have offered interpretations. UK patent law ties inventorship to devising the inventive concept, while the German Federal Supreme Court focuses on solving a technical problem using specific means. Inventorship is not necessarily linked to autonomy, implying that AI could be considered inventors if they contribute to the invention process. However, this raises issues about the ownership and protection of AI-generated inventions, suggesting that current patent laws may need to be updated to reflect these developments (Martin Stierle, ‘A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System’ (2021) *GRUR International* 115; for more on the ownership dilemma see, for example: Deepak Somaya and Lav R Varshney, ‘Ownership Dilemmas in an Age of Creative Machines’ (2020) 36(2) *Winter Issues in Science & Technology* 79 et seq.).

⁴³⁷ Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 39-42.

said to extend to the subsequent outputs of the AI tool.⁴³⁸ However, this argument becomes increasingly strained when AI systems produce outputs far beyond the foresight or capacity of the original human contributor.

The application of the natural rights theory to AI-related inventions presents significant challenges.⁴³⁹ As AI systems become more autonomous, the link between human labour and invention becomes increasingly tenuous, calling into question the applicability of *Locke's* labour theory. However, the underlying principles remain relevant and there remains a compelling pragmatic argument for protection. Consider, for example, a scenario in which an AI autonomously discovers a universal cure for cancer. Even if this breakthrough cannot be justified under the natural rights framework, the case for granting patent protection, so as to secure dissemination, investment, and structured access, may nonetheless appear morally and socially desirable.⁴⁴⁰

c) The Disclosure Theory

aa) Overview of the Theory

The disclosure theory conceptualises the patent system as a mechanism to enhance the public pool of technical knowledge.⁴⁴¹ The theory assumes that inventors tend to keep their inventions secret.⁴⁴² However, the prospect of obtaining a patent motivates them to disclose the underlying technical knowledge through a patent application. As a result, the general state of the art becomes more comprehensive and accessible. Without a patent system, society would only gain access to such knowledge at a significantly later stage and at higher financial costs.⁴⁴³ Yet,

⁴³⁸ Reto Hilty, Jörg Hoffmann and Stefan Scheuerer, 'Intellectual Property Justification for Artificial Intelligence' (MPI Research Paper No. 20-02, 24 February 2020) 10.

⁴³⁹ Kaitlin Luse, 'The Return of the Machinery Question: Is It Different This Time?' (2017) 9 *Major Themes in Economics* 1 et seq. <https://scholarworks.uni.edu/mtie/vol19/iss1/3/>.

⁴⁴⁰ This scenario most strongly aligns with the utilitarian justification for patent law, particularly in its focus on incentivizing innovation for societal benefit. Once created, even if on accident, patenting the cure is likely the general purpose. Research and development leading to discovery, even if intended for a different one, just prompts investing more on clinical trials and more work to release the invention. Without an approach to profit on the patent the creator would likely never invest on most of the workers and organization that leads to the cure. The race to be the first to invent such a cure would likely make emerge also all other sorts of inventions, that humanity could profit from. By giving inventors a patent and giving them a chance to have a temporary right on the invention, innovation is stimulated. An incredible expensive to research and develop cure for cancer serves as a prime example of the incentive and reward rationale behind the patent framework and illustrates why it should be extended to AI-related inventions (see amongst others: Albert Hu and Ivan Png, 'Patent Rights and Economic Growth: Evidence from Cross-Country Panels of Manufacturing Industries' (2013) 65(3) *Oxford Economic Papers* 675; Paul Belleflamme, 'Patents and Incentives to Innovate: Some Theoretical and Empirical Economic Evidence' (2006) 13 *Ethical Perspectives* 278).

⁴⁴¹ See Douglas G Lichtman and Scott Baker, 'Strategic Disclosure in the Patent System' (Coase-Sandor Working Paper Series in Law and Economics No 107, 1-3, 2000); for the importance of disclosure from a public welfare standpoint, see Peter K Yu, *Intellectual Property and Information Wealth: Issues and Practices in the Digital Age* (vol 2, Greenwood Publishing Group 2007) 115-118.

⁴⁴² Werner Siemens (ed), *Positive Vorschläge zu einem Patent-Gesetz: Denkschrift der Ältesten der Kaufmannschaft zu Berlin* (Berlin 1869) 7; Hans-Joachim Sellnick, 'Erfindung, Entdeckung und die Auseinandersetzung um die Umsetzung der Biopatentrichtlinie der EU' (2002) *GRUR* 126.

⁴⁴³ Carl Pieper, *Der Erfinderschutz und die Reform der Patentgesetze: Amtlicher Bericht über den Internationalen Patent-Congress zur Erörterung der Frage des Patentschutzes* (Dresden 1873) 259.

timely access to technical knowledge is considered vital, as it provides a foundation for further research and cumulative innovation.⁴⁴⁴

Two key conceptual metaphors illustrate the essence of this theory. First, inventors were portrayed as “teachers of the nation”, disseminating knowledge in exchange for exclusive rights.⁴⁴⁵ Second, the theory, as it is also intended to promote the public good, is also known as, drawing on *Rousseau*, the “contract theory”.⁴⁴⁶ It views patents as the product of a reciprocal arrangement: the inventor publicly discloses their invention, and in return, receives a temporary monopoly.⁴⁴⁷

Although the terms “disclosure theory” and “contract theory” are still in use today, the concept has increasingly been referred to as the “information function”, a term introduced by *Beier*.⁴⁴⁸ The theory remains influential, either as a standalone rationale or in conjunction with others, in justifying the patent system. In economics, the information function has also received considerable attention. From an incentive-based perspective, it can be seen as creating a disclosure or information incentive, akin to the reward mechanism articulated by the classical incentive theory.⁴⁴⁹

bb) Application of the Theory to AI

This theory finds a particularly pertinent application in the context of AI inventions, where the rapid pace of technological advancement and competitive secrecy are significant. In the field of AI, inventors might naturally prefer to maintain proprietary algorithms, models, or datasets as trade secrets to retain competitive advantage. However, the promise of exclusive rights under patent law encourages disclosure of AI-related inventions. This trade-off promotes a richer public repository of AI knowledge, which can be accessed by other researchers and developers once patent documents are published, thus advancing the overall technical landscape. It also supports the argument for granting protection to AI-related inventions, as otherwise, the owner of the AI system, or any person who becomes aware of the technical teaching, may have an incentive to keep such information confidential.⁴⁵⁰ It would therefore be more appropriate to confer a protective right in return for the disclosure of a technical teaching developed in this manner.⁴⁵¹

Still, the theory encounters challenges when applied to AI inventions. One line of critique observes that even in the context of publicly funded research, disclosure is frequently postponed

⁴⁴⁴ Josef Kohler, *Deutsches Patentrecht systematisch bearbeitet unter vergleichender Berücksichtigung des französischen Patentrechts* (Mannheim 1878) 25.

⁴⁴⁵ Felix Damme, *Das Deutsche Patentrecht* (Berlin 1906) 15.

⁴⁴⁶ Otto Bossung, ‘Die Rechtsnatur der Patenterteilung - Nach deutschem und ausländischem Recht’ (1958) *GRUR International* 289 et seq.

⁴⁴⁷ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 207.

⁴⁴⁸ Friedrich K Beier und Joseph Straus, ‘Das Patentwesen und seine Informationsfunktion’ (1977) *GRUR* 282.

⁴⁴⁹ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 208.

⁴⁵⁰ Sven Hetmank and Anne Lauber-Rönsberg, ‘Künstliche Intelligenz - Herausforderungen für das Immaterialgüterrecht’ (2018) *GRUR* 579 et seq.

⁴⁵¹ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 406.

until patent protection has been secured.⁴⁵² Moreover, as in other technological fields, the contractual notion embedded in the theory, that patent disclosure occurs as a *quid pro quo* for patent rights, is complicated by the fact that patent applications are published 18 months after filing regardless of patent grant.⁴⁵³ The so called principle of file inspection, available no later than 18 months following the filing date pursuant to Article 93(1)(a) EPC, can be seen as undermining the core logic of the disclosure theory.⁴⁵⁴ Under current practice, the invention is made public prior to the grant of the patent, including in cases where the application is ultimately rejected.⁴⁵⁵ Nevertheless, this does not negate the fact that patents continue to facilitate the dissemination of technical teachings, although sometimes only at a later stage. As a result, the patent system still contributes to a cumulative expansion of technological knowledge that would likely not occur in its absence.⁴⁵⁶

Second, the actual incremental information contributed by AI patent disclosures can be questioned. Given that many AI innovations are made possible by complex algorithms or data-driven processes that may be difficult to fully capture in patent specifications, the sufficiency and practical utility of disclosed information may be limited. This may result in incomplete or opaque disclosures that hinder effective replication or further development. Third, the rapid obsolescence of AI technology means that disclosed information can become outdated quickly, potentially reducing the relevance of the patent documents by the time they become publicly accessible. However, the delay in disclosure is a necessary compromise to balance inventors' incentives with public access. Finally, the cost-benefit ratio of the patent system, when applied to AI inventions, is subject to ongoing debate. While the information disclosure function promises benefits to society through knowledge diffusion, the high costs of patent prosecution and potential for patent thickets in AI may offset these gains. However, even if empirical evidence on net benefits remains mixed, the normative value of promoting public disclosure remains a cornerstone of patent policy.

The disclosure theory can therefore, at least in principle, be applied to AI-related inventions. However, its applicability reaches limits where either genuine secrecy is not feasible or the quality of disclosure remains insufficient. When viewed in aggregate, it can nevertheless be assumed that the patent system creates a positive information equilibrium even in the field of AI: it increases the likelihood that technical teachings are published at all and at an earlier stage, whether directly through patent applications or indirectly via related follow-up publications. Thus, the normative function of disclosure is not rendered obsolete by AI-related inventions but rather is modified in light of the specific characteristics of the technology.

⁴⁵² Niclas Kunczik, 'Die Legitimation des Patentsystems im Lichte biotechnologischer Erfindungen' (2003) *GRUR* 847.

⁴⁵³ Article 93(1)(a) EPC; see also: EPO Guidelines 2025, Part A-XI, 2.

⁴⁵⁴ *Ibid.*

⁴⁵⁵ Joseph Straus and Rainer Moufang, *Hinterlegung und Freigabe von biologischem Material für Patentierungszwecke: Patent- und eigentumsrechtliche Aspekte* (Baden-Baden 1989) 36 et seq.

⁴⁵⁶ Friedrich K. Beier, 'Die herkömmlichen Patentrechtstheorien und die sozialistische Konzeption des Erfinderrechts' (1970) *GRUR International* 4.

d) The Incentive Theory

aa) Historical Context and Modern Applications

One of the most historically significant theories is the incentive theory, which continues to be the most widely endorsed foundation of the current patent system among legal and economic scholars who support patent protection.⁴⁵⁷ Unlike earlier theories with a deontological orientation, the incentive theory is teleological in nature. Its primary objective is to promote technological progress and, by extension, broader economic development. *Lincoln* eloquently stated that the patent system “added the fuel of interest to the fire of genius”, viewing it as a tool to encourage innovation, foster the development of new technologies, and enrich knowledge.⁴⁵⁸

This theory has been particularly enriched by developments in the property rights movement and the economic theory of goods from the mid-20th century onward.⁴⁵⁹ These approaches begin with the problem of the overuse of common goods: rational actors, aiming to maximise individual gains, tend to overexploit shared resources, especially when they can do so without incurring direct personal costs.⁴⁶⁰ This dynamic leads to the so-called “tragedy of the commons”. However, privatisation of such goods, through the grant of exclusive rights, prevents overuse by ensuring that the costs of use are internalised by each individual user, thereby discouraging depletion.⁴⁶¹ Although commons are rivalrous in consumption, inventions, understood as technical information, constitute public goods.⁴⁶² Nevertheless, similar inefficiencies may arise in the form of underproduction, as described by *Demsetz*: if new ideas are freely accessible and no private rights are granted, there is little incentive to invest in their development.⁴⁶³ In the absence of rights, free riders can appropriate inventions without compensating the originator, thereby undermining incentives for innovation.⁴⁶⁴ The prospect of obtaining a patent counteracts this market failure by offering inventors the opportunity to regain their sunk costs, thus encouraging the production of technical knowledge. A property right over inventions, although introducing static inefficiencies by limiting access, corrects the underproduction problem by creating dynamic efficiencies. Without such rights, the level of invention would be suboptimal.⁴⁶⁵

⁴⁵⁷ See amongst others: Karl H Rau, *Lehrbuch der politischen Ökonomie* (Heidelberg 1839) 318 et seq.; Werner Siemens (ed), *Positive Vorschläge zu einem Patent-Gesetz: Denkschrift der Aeltesten der Kaufmannschaft zu Berlin* (Berlin 1869) 8.

⁴⁵⁸ Early in his career, Lincoln worked on a Mississippi ferry boat that repeatedly ran aground. He created a system to buoy vessels across shoals as a result of being inspired by the technological challenge the problem posed. When the crew needed to elevate the ship over a shallow stretch of water, his technology allowed them to inflate watertight fabric bladders. When he was granted patent number 6,469 for the concept on 22 May 1849 he expressed his pride with this now famous quote. (‘President Lincoln and the “Fire of Genius”’ (Intellectual Ventures, 11 February 2016) <https://www.intellectualventures.com/buzz/insights/president-lincoln-and-the-fire-of-genius>).

⁴⁵⁹ Garrett Hardin, ‘The Tragedy of the Commons’ (1968) *162 Science* 1243.

⁴⁶⁰ *Ibid.*, 1244.

⁴⁶¹ *Ibid.*

⁴⁶² Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 198 et seq.

⁴⁶³ Harold Demsetz, ‘Toward a Theory of Property Rights’ (1967) *57(2) The American Economic Review* 359.

⁴⁶⁴ William M Landes and Richard A Posner, *The Economic Structure of Intellectual Property Law* (Harvard University Press 2003) 11.

⁴⁶⁵ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 200.

Distinct critiques can be identified, as elaborated by *Stierle*, each reflecting different lines of argument concerning the necessity and effectiveness of the patent system.⁴⁶⁶

The first concerns the incentive provided by existing funding mechanisms. In this view, a patent system is deemed superfluous, as alternative models, such as intrinsically motivated innovation structures (for example, open-source development), allegedly offer sufficient incentives for invention.⁴⁶⁷ However, this argument is dismissed as lacking general applicability. The logic underpinning open-source innovation cannot be transferred to the majority of technological domains, particularly those in which high development costs require capital amortisation to be economically viable.⁴⁶⁸

The second centres on the incentive arising from competitive market dynamics (status quo).⁴⁶⁹ It is argued that the existing competitive pressure within markets already generates adequate motivation to innovate, rendering additional state intervention through patent rights unnecessary. This line of reasoning is exposed as circular. The very innovation-driven market competition cited as evidence is itself shaped by the existence of patent protection.⁴⁷⁰ Without such protection, competitive dynamics would shift towards mere imitation. Thus, it is the patent system that establishes the structural preconditions for the innovation pressure it is accused of redundantly reinforcing.⁴⁷¹

The third addresses the incentive stemming from a first-mover advantage.⁴⁷² Here, it is claimed that a temporal lead in the market yields sufficient economic returns, thereby obviating the need for patent protection. This argument is also relativised. While certain markets (for example mobile communications) exhibit significant pioneer advantages, in others, the benefits tend to accrue to late entrants.⁴⁷³ Examples such as Amazon and Microsoft illustrate that early movers are frequently displaced by more strategically positioned competitors.⁴⁷⁴ Consequently, in at least some technological sectors, patents remain essential to ensure that investments in innovation are economically justifiable.⁴⁷⁵

Finally, the incentive theory posits that patents primarily serve to motivate the generation of inventions by offering exclusive rights as an incentive. Although some inventions arise independently of patent incentives, the theory maintains that patents encourage inventive

⁴⁶⁶ Ibid; 200 et seq.

⁴⁶⁷ See also: Axel Metzger, 'Innovation in der Open Source Community. Herausforderungen für Theorie und Praxis des Immaterialgüterrechts' in M Eifert and W Hoffmann-Riem (eds), *Geistiges Eigentum und Innovation* (Berlin 2008) 194 et seq.

⁴⁶⁸ Margit Osterloh and Roger Luethi, 'Commons without Tragedy: Das Beispiel Open Source Software' in M Eifert and W Hoffmann-Riem (eds), *Geistiges Eigentum und Innovation* (Berlin 2008) 160 et seq.

⁴⁶⁹ Michele Boldrin and David K Levine, 'The Case against Patents' (2013) 27(1) *Journal of Economic Perspectives* 3 et seq.

⁴⁷⁰ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 201.

⁴⁷¹ Günter Knieps, *Wettbewerbsökonomie* (Berlin and Heidelberg 2008) 6.

⁴⁷² Marvin B Lieberman and David B Montgomery, 'First-Mover Advantages' (1988) 9 *Strategic Management Journal* 41.

⁴⁷³ Justus Haucap and Ralf Dewenter, *First-Mover Vorteile im Schweizer Mobilfunk* (HSU Hamburg) 7, 14; Mark A Lemley, 'The Surprising Virtues of Treating Trade Secrets as IP Rights' (2010) 61(2) *Stanford Law Review* 311, 330.

⁴⁷⁴ Constantinos C Markides and Paul A Geroski, *Fast Second: How Smart Companies Bypass Radical Innovation to Enter and Dominate Emerging Markets* (Jossey-Bass 2005) 65 et seq.

⁴⁷⁵ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 201.

activity by compensating innovators for their efforts. Challenges exist in distinguishing patent-induced from non-patent-induced inventions, and protecting all inventions regardless of their inducement does not contradict the incentive logic due to practical and economic considerations. The classical incentive theory assumes that patents have positive economic effects before grant (by spurring invention) and negative effects after grant (by limiting competition).⁴⁷⁶ Critics argue that the negative impacts often outweigh the positives, especially given the “one size fits all” nature of patent law that applies uniformly across diverse technologies. Nonetheless, the normative purpose of patents as an incentive mechanism remains valid, even if empirical outcomes diverge from the theoretical ideal. A critique of the incentive theory is that it conflates invention (technical idea) with innovation (commercialized product), whereas only the latter results in tangible technical progress and societal benefit.⁴⁷⁷ The incentive theory traditionally focuses on invention generation but insufficiently accounts for the commercial development of inventions into innovations. However, commercialization theories complement the incentive theory by addressing this latter stage, and invention remains a necessary prerequisite for innovation.⁴⁷⁸

The present European patent system is based primarily on incentives: acquiring ownership of patents is often the result of investments in research and development.⁴⁷⁹ Although the ways in which research and innovation are organized have changed over time, the fundamental goal of encouraging inventive talents remains constant.⁴⁸⁰ Both EU directives (for example the Biotechnology Directive and Enforcement Directive) and the TRIPS Agreement reflect normative support for the incentive theory by emphasizing patent protection as a tool to promote investments in technological progress. These legal instruments reference both inventions and innovations, reinforcing the idea that patent protection incentivizes technological development, even if the precise conceptual distinction between invention and innovation remains ambiguous.⁴⁸¹

bb) The Incentive Theory Applied to AI and AI-Related Inventions

The incentive theory considers both pre-invention motivation and post-invention rewards. As pre-invention motivation, the incentive theory is adaptable to AI by focusing on incentives for AI development and deployment of AI systems. It can be broadly applied to both the AI system and AI-related inventions by considering the incentives for humans to develop and use AI for inventions. It accounts for multiple stakeholders in the AI innovation process, including developers, users, and investors.

⁴⁷⁶ Ibid., 204.

⁴⁷⁷ See for example: Fritz Machlup, ‘Die Wirtschaftlichen Grundlagen des Patentrechts - 1. Teil’ (1961) *GRUR Ausland* 377.

⁴⁷⁸ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 205.

⁴⁷⁹ For more on the debate of ownership and AI see: Francesco Banterle, ‘Ownership of Inventions Created by Artificial Intelligence’ (1 November 2018) *AIDA* <https://ssrn.com/abstract=3276702>.

⁴⁸⁰ Fritz Machlup, *An Economic Review of the Patent System* (Committee Print, Washington 1958) 23-36.

⁴⁸¹ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 206.

While AI systems, once operational, reduce the marginal cost of producing inventions and do not themselves require incentives, the creation of such AI systems, especially those capable of producing patentable outputs, need substantial human and financial investment. These include costs associated with highly skilled personnel, access to large datasets, and computational infrastructure.⁴⁸² The essential question, therefore, is whether such AI systems would be developed without the possibility of securing patent protection for their outputs.⁴⁸³ Arguably, the answer is negative. Even though AI transforms the inventive process from a resource-intensive model into one driven by automated data analysis, thereby significantly reducing production costs and time, patent protection remains essential to incentivise the initial development of the AI technology itself.

A significant determinant of the incentive to innovate under a patent regime lies in the magnitude of the investment required for the development of an invention. From an economic standpoint, such expenditures are classified as sunk costs, which are costs that will only be incurred if the investor anticipates at least a partial recoupment through subsequent commercial utilisation of the invention.⁴⁸⁴ Consequently, the scale of the investment needed directly shapes the incentive effect patents can exert. The higher the investment costs, the greater the likelihood that inventive activity will be foregone in the absence of a compensatory legal mechanism such as patent protection. Conversely, where the financial and risk burden of invention is relatively low, inventive efforts are more likely to be undertaken even without the expectation of exclusive rights.⁴⁸⁵ The grant of exclusive rights over AI-generated inventions thus acquires an independent value, serving as an *ex ante* incentive for the construction of systems capable of producing such inventions.⁴⁸⁶

Classifying AI inventions as patentable aligns with the objective of the incentive theory, which is to promote innovation through incentive structures.⁴⁸⁷ Granting patents for inventions

⁴⁸² Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1458.

⁴⁸³ Deepak Somaya and Lav R Varshney, 'Embodiment, Anthropomorphism, and Intellectual Property Rights for AI Creations' in *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society* J Furman, G Marchant et al (eds) *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society* (AIE'S 2018) 278 et seq.

⁴⁸⁴ Hans-Bernd Schäfer and Claus Ott, *Lehrbuch der ökonomischen Analyse des Zivilrechts* (4th edn, Berlin and Heidelberg 2012) 669.

⁴⁸⁵ Oskar Paulini, 'Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz' 23 (PhD thesis, LMU Munich 2023) 225.

⁴⁸⁶ According to a study dedicated to the impact of AI conducted by the McKinsey Global Institute titled "Notes from the frontier: Modelling the impact of AI on the world economy", which measured, through a series of hypotheses and simulations, the degree of adoption of AI technologies by companies and countries, estimating their economic returns, AI is a system designed to bring enormous economic benefits to those - individual companies or the entire country - is focusing today on innovation by investing adequate resources. Vice versa, those who do not immediately get on the train are fated to remain behind, losing ground compared to the competition. According to the study, by 2030 the widespread adoption of AI could generate for the economy at a global level an additional value equal to \$ 13,000 billion, which resembles 1.2% annual additional growth for the world Gross Domestic Product. The pace of adoption of AI by companies, and the priority they give to innovation and efficiency objectives, are likely to have a strong impact on their economic performance: front-runners could potentially double their cash flow by 2030. Conversely, companies that do not adopt AI technologies or that have not fully absorbed them could experience a drop in their cash flow of up to 20% compared to current levels. (Manuela Gianni, 'McKinsey Stima il Ritorno degli Investimenti in AI: "Potenziale Raddoppio del Cash Flow Entro il 2030"' (Digital4Executive, 19 November 2018)).

⁴⁸⁷ Colin R Davies, 'An Evolutionary Step in Intellectual Property Rights - Artificial Intelligence and Intellectual Property' (2011) 27(6) *Computer Law & Security Review* 601.

generated by AI would create value that extends beyond the capabilities of the AI itself, effectively rewarding the human innovation embedded in the development of such systems.⁴⁸⁸ While AI systems are not themselves responsive to incentives, the availability of patent protection would stimulate investment in the creation of inventive machines by computer scientists. Given that the development of creative AI systems entails substantial resource expenditure, particularly in terms of specialised labour and computational capacity, financial incentives are likely to play a crucial role in this domain.⁴⁸⁹ Although some incentive to develop such technologies may persist even if AI-generated inventions were patentable but AI could not be designated as an inventor, such a framework would provide weaker motivation due to practical, normative, and efficiency-related challenges. Thus, the lack of patent rights may inhibit firms from investing in the commercial development of AI-related inventions.⁴⁹⁰ This concern is particularly pronounced in sectors where the majority of financial investment arises post-invention, during the extensive regulatory processes required for market approval.⁴⁹¹

Moreover, as an *ex post*-invention mechanism, the incentive theory highlights the long-term effects of patent protection on innovation and investment in research and development.⁴⁹² Particularly in the AI field, where significant resources are devoted to both the creation and implementation of tools, market actors require reliable expectations of return on investment. This includes not only coverage of actual and opportunity costs but also a risk-adjusted premium for engaging in uncertain innovation.⁴⁹³ The patent system thus serves a compensatory function, enabling states or intergovernmental bodies to reward private investments through the temporary grant of exclusive rights, thereby promoting sustained engagement with complex and capital-intensive technological domains.⁴⁹⁴

Against this backdrop, patenting AI-related inventions could foster research, reduce reliance on trade secrets and facilitate the more rapid generation of inventions while lowering associated costs.⁴⁹⁵ This would benefit society not only by accelerating research, but also because AI systems are capable of linking data across different domains in ways that may elude human capacity, potentially leading to groundbreaking innovations. Although the underlying legal and technical challenges are significant, a well-calibrated patent framework could support both the

⁴⁸⁸ Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1079, 1104 et seq.

⁴⁸⁹ David Ferrucci et al., 'Building Watson: An Overview of the DeepQA Project' (2010) 31(3) *AI Magazine* 59.

⁴⁹⁰ Edmund W Kitch, 'The Nature and Function of the Patent System' (1977) 20 *Journal of Law and Economics* 276-277.

⁴⁹¹ Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1079, 1105.

⁴⁹² Daniel F Spulber, 'How Patents Provide the Foundation of the Market for Inventions' (2014) 11(2) *Journal of Competition Law & Economics* 286; Krithika Krishna and Shiju S Philip, 'The Path to Innovation: An Amalgamation of Patent Law and the Dynamic Competition Regime' (2015) 4(2) *Christ University Law Journal* 89 et seq.

⁴⁹³ Yusing Ko, 'An Economic Analysis of Biotechnology Patent Protection' (1992) 102(3) *The Yale Law Journal* 777 et seq. https://www.jstor.org/stable/796918?seq=1#metadata_info_tab_contents.

⁴⁹⁴ 'Time to fix patents' (The Economist, 8 August 2015) <https://www.economist.com/news/leaders/21660522-ideas-fuel-economy-todays-patent-systems-are-rotten-way-rewarding-them-time-fix?fsrc=scn/tw/te/pe/st/timetofixpatents>; of opposite view see: Gene Quinn, 'What "The Economist" Doesn't Get About Patents' (IPWatchDog, 13 August 2015) <https://ipwatchdog.com/2015/08/13/what-the-economist-doesnt-get-about-patents/id=60626/>.

⁴⁹⁵ On the benefits of allowing patents for AI-related inventions see: Ryan Abbott, 'Allow patents on AI-generated inventions – for the good of science' (2023) *Nature* 699.

dissemination and acceleration of AI-driven innovation. Nonetheless, this general justification, however, does not apply equally across all AI-related inventions. In light of the different categories of AI involvement in the inventive process, the applicability of the incentive theory is uneven. Inventions falling under Categories I-III are typically the result of direct and purposeful human work. Here, the incentive theory offers a strong rationale for patent protection, as the human contribution is both identifiable and intentional. In contrast, Category IV-V inventions raise critical challenges for the incentive theory. In such cases, the inventive step is either partially or entirely dissociated from a specific human contribution, calling into question whether the reward structure of the patent system continues to serve its original motivational function.

Although the incentive theory continues to offer valuable insights, its explanatory and justificatory power appears strongest in cases where humans remain central to the inventive act. The applicability of this theory to AI-related inventions remains uncertain. As AI systems lack consciousness, they cannot be motivated or incentivised in the conventional sense.⁴⁹⁶ Therefore, any incentive derived from the patent system must be directed at a natural person, either directly or through their organisational role within a legal entity. Considering that over 80% of patented inventions originate from employees, it may be questioned whether the system is even designed to incentivise the individual inventor.⁴⁹⁷ Instead, it appears that the patent holder, typically the employer, benefits from the protection by being able to commercialise inventions developed by their employees or technical systems.⁴⁹⁸ Against this backdrop, there appears to be no substantive difference between relying on human labour and utilising AI systems in the innovation process. Furthermore, the existence of a legal protection regime itself serves as a motivator, especially by encouraging further investment in technological development, thereby fostering the emergence of novel and inventive solutions.⁴⁹⁹

3. Preliminary Results

The patent system has historically evolved alongside economic development, strengthening over time by increasing the number of patents, expanding the scope of what can be patented, extending patent duration, and reducing administrative costs. Still, the rules for patent protection have remained largely unchanged since the industrial era, despite significant technological advancements.⁵⁰⁰ Today's economy, characterized by the service economy, digital technologies, and globalization, poses new challenges. Concerns have arisen over patent prosecution delays, the standard 20-year patent lifespan, and the eighteen-month publication

⁴⁹⁶ Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für Geistiges Eigentum* 407.

⁴⁹⁷ Kurt Bartenbach und Franz-Eugen Volz, *Arbeitnehmererfindungsgesetz* (5th edn, Cologne 2013) § 11 para 6.

⁴⁹⁸ Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für Geistiges Eigentum* 407.

⁴⁹⁹ Ibid.

⁵⁰⁰ William W Fisher, 'Theories of Intellectual Property' in S Munzer (ed.), *New Essays in the Legal and Political Theory of Property* (Cambridge University Press 2001) 169-175; Justin Hughes, 'The Philosophy of Intellectual Property' (1988) 77 *The Georgetown Law Journal* 288-89.

delay of patent applications, which can prompt unnecessary parallel research and development efforts.⁵⁰¹

The traditional justifications for patent protection, namely, the reward-by-monopoly theory, natural rights theory, disclosure theory and incentive theory, remain conceptually relevant. However, each theory faces specific limitations when applied to AI-related inventions.

For example, the reward-by-monopoly theory, which frames patent rights as a form of retrospective compensation for intellectual labour, struggles to accommodate the emergence of autonomous AI systems that lack the consciousness or moral agency presupposed by this framework. While human actors may contribute at peripheral stages, such as curating input data or validating outputs, these efforts complicate the identification of a deserving recipient for the reward. Furthermore, institutional patent ownership and investor-driven innovation call into question the moral premise of individual entitlement.

Similarly, the natural rights theory, which is based on Lockean principles, presupposes a human labourer who combines their intellectual efforts with unclaimed resources. While this theory might justify protection for human-facilitated AI inventions, it becomes increasingly untenable in contexts where human intervention is minimal or absent. The result is a conceptual gap between the traditional notion of labour-based entitlement and the operational realities of AI-driven innovation.

In contrast, the disclosure theory largely retains its functional value. By requiring the public dissemination of technical information, it supports cumulative innovation and mitigates the risks of proprietary stagnation. However, in the context of AI, its effectiveness is undermined by factors such as delayed publication, opaque algorithmic processes and insufficient disclosed material for replication. Nevertheless, it still provides a rationale for forward-looking patent protection in this domain.

In the context of AI, the incentive theory remains the most adaptable and empirically grounded justification. It emphasises the importance of securing exclusive rights as a means of offsetting high research and development costs and attracting investment, particularly when creating inventive AI systems involves significant human and financial input. However, its persuasive force diminishes in cases where AI operates with a high degree of autonomy and human involvement in the inventive process is minimal or absent.

Overall, these theoretical approaches demonstrate that, although the fundamental principles of patent law continue to provide valuable insights into the regulation of AI-related inventions, their application necessitates refinement. None of the classical theories provide unequivocal support for or against the patentability of AI-generated outputs. Instead, a nuanced, selective approach sensitive to the degree and nature of human involvement appears necessary to

⁵⁰¹ Jochen Ehlers et al., ‘European Patent Office’, in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 116.

preserve the normative integrity and functional efficacy of the patent system in the age of artificial intelligence.

II. An Overview of the Current Applicable Patent Frameworks

1. International Context

The World Intellectual Property Organization (WIPO), established in 1967, is a specialized agency of the United Nations and currently has 193 Member States. The treaties the WIPO administers, together with national and regional laws, make up the legal framework for patents.⁵⁰² The organisation does not grant patents per se. Member States collaborate on treaties and conventions that shape the international framework for patent law, which will be elaborated upon further in the following sections. The WIPO moreover offers a wide range of facilitations for international patent protection under the Patent Cooperation Treaty, with services available at a national and regional level. The grant of a patent for an invention confers exclusive rights on the national territory,⁵⁰³ but through international treaties, exclusivity can be achieved in other countries as well.⁵⁰⁴

The Paris Convention for the Protection of Industrial Property (Paris, 1883)⁵⁰⁵ grants patent applicants in one of the Member States of the Paris Union a right of priority for filing in the other countries within twelve months of the first filing.⁵⁰⁶ The inventor must submit separate applications for each country, according to the national procedures, but the novelty of the invention is assessed by reference to the date of the first filing. The inventor will thus obtain separate national patents, regulated in all respects by individual national laws.⁵⁰⁷

The Patent Cooperation Treaty (Washington, 1970) allows for a simplification of the procedure for filing international patent applications in contracting states.⁵⁰⁸ It assists applicants in seeking patent protection internationally, helps patent offices with granting decisions, and facilitates public access to information. By filing an international patent application under the Patent

⁵⁰² WIPO, 'Patents' <https://www.wipo.int/patents/en/>; for a more nuanced analysis of the international intellectual property legislative framework, see: Estelle Derclaye and Matthias Leistner, *Intellectual Property Overlaps: A European Perspective* (Hart Publishing 2011).

⁵⁰³ Patents are territorial rights, meaning they are only valid and enforceable within the country or jurisdiction that granted them (Article 4bis(1) of the Paris Convention; on the topic see also: Lydia Lundstedt, *Territoriality in Intellectual Property Law* (Stockholm University 2016) 91).

⁵⁰⁴ For a general discussion see: Christoph Kilchenmann, *Patentschutz und Innovation: Eine ökonomische Analyse aus globaler und nationaler Sicht* (Peter Lang 2011) 10 et seq.; Sava Kulhavy, *Erfindungs- und Patentlehre: Methodik der Behandlung von Erfindungen und Patenten* (Carl Heymanns, Cologne 2009) 24 et seq.

⁵⁰⁵ Paris Convention for the Protection of Industrial Property (adopted 20 March 1883, last amended 28 September 1979) 828 UNTS 305.

⁵⁰⁶ United Nations Industrial Development Organization, 'Paris Convention for the Protection of Industrial Property of March 20, 1883, as revised' https://www.unido.org/sites/default/files/2014-04/Paris_Convention_0.pdf.

⁵⁰⁷ WIPO, 'Summary of the Paris Convention for the Protection of Industrial Property (1883)' (WIPO, 2024) https://www.wipo.int/treaties/en/ip/paris/summary_paris.html.

⁵⁰⁸ Patent Cooperation Treaty (adopted 19 June 1970, entered into force 24 January 1978) 1160 UNTS 231.

Cooperation Treaty, applicants can simultaneously seek protection for an invention in member countries.⁵⁰⁹

A foundational benchmark is also established by the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), enacted in 1994 under the auspices of the World Trade Organization (WTO).⁵¹⁰ As delineated in Article 27 TRIPs, patents are accessible for all types of inventions across technological domains, contingent upon their novelty, inventive nature, and industrial applicability.⁵¹¹ Subsequently, Article 27(2) TRIPs empowers member nations to designate certain inventions as ineligible for patent protection. Moreover, Article 29 TRIPs highlights the imperative of transparency and completeness in patent disclosure, emphasizing that applicants must furnish sufficient information for a skilled artisan to replicate the invention effectively.⁵¹² These provisions are of particular importance for this work, since they mirror the provisions of the EPC.

2. United States

In the United States a patent for an invention is issued by the United States Government through the United States Patent and Trademark Office (USPTO). Patents are governed exclusively by federal law, as established in Title 35 United States Code (USC). This means that patent rights are uniform across all states and territories of the United States, providing consistency in their application and enforcement.⁵¹³ The patent provides the “right to exclude others from making, using, offering for sale, or selling the invention throughout the United States”, or from “importing” it into the country.⁵¹⁴ This grant does not confer the right to make, use, offer for sale, sell, or import the invention, but rather the right to exclude others from engaging in these activities.⁵¹⁵ The United States Constitution gives Congress the mandate to enact patent laws, as reflected in Article 1, Section 8, Clause 8.⁵¹⁶ Availing itself of this legislative authority, Congress has implemented various provisions governing the patent system. The first law dates back to 1790; subsequent regulatory amendments were implemented in 1952 and became effective in January 1953. In addition, on 29 November 1999, Congress enacted the American Inventors Protection Act, which further amended the patent law.⁵¹⁷ The patent legislation

⁵⁰⁹ WIPO, ‘PCT - The International Patent System’ <https://www.wipo.int/pct/en/>.

⁵¹⁰ Agreement on Trade-Related Aspects of Intellectual Property Rights (adopted 15 April 1994, entered into force 1 January 1995) 1869 UNTS 299; for more on the foundations of TRIPs see, for example: Ullrich, Hanns, ‘The Political Foundations of TRIPS revisited’ in Hanns Ullrich, Reto Hilty and Matthias Lamping (eds), *TRIPS plus 20* (Berlin and Heidelberg 2016) 85; see also: Donald S Chisum, ‘Patentability Under TRIPS: The Need for Uniformity’ (2006) 2(1) *Indian Journal of Law and Technology* 1 et seq.

⁵¹¹ Xuebing Yang, ‘Horizontal inventive step and international protection of intellectual property’ (2013) 25 *International Review of Economics & Finance* 338 et seq.

⁵¹² Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 79.

⁵¹³ USPTO, ‘Patents’, <https://www.uspto.gov/ip-policy/patent-policy/patents>.

⁵¹⁴ 35 USC § 154(1).

⁵¹⁵ *Ibid.*

⁵¹⁶ This provision is referred to as the “Patent Clause” or the “Intellectual Property Clause” and provides the constitutional basis for the United States patent system (see Edward C Walterscheid, ‘To Promote the Progress of Science and Useful Arts: The Background and Origin of the Intellectual Property Clause of the United States Constitution’ (1994) 2(1) *Journal of Intellectual Property Law* 56).

⁵¹⁷ Public Law 106-113, 113 Stat 1501 (1999).

specifies what constitutes patentable subject matter and the requirements for patentability. The legislative dictate defers to the USPTO the power to regulate the issuance of patents and various other provisions relating to the subject matter.⁵¹⁸

3. Europe

a) The European Patent System

Following World War II, the Council of Europe identified patent law harmonization as one of the priorities for Europe's reconstruction, with the main objective of strengthening the operation of the Internal Market (Article 3(3) TEU).⁵¹⁹ Still, contrary to common belief, the EU never codified patent law *per se* and is not a member of the EPC. To this day, European patent law consists mainly of national patent laws, and legislation as the Strasbourg Convention (1963), the EPC (1973),⁵²⁰ and several EU directives and regulations.⁵²¹

Patents are typically filed either at the national level or via the EPO. Although the EPO facilitates the grant of patents across multiple European states, it is not an institution of the European Union, but rather a public international organisation established under the EPC.⁵²² Through a single application and a unitary examination procedure administered by the EPO in Munich, applicants may obtain protection in multiple EPC Member States.⁵²³

However, the patent granted by the EPO does not result in a unitary right; rather, it gives rise to a bundle of national patents, each enforceable separately before national courts and subject to divergent procedural and substantive rules. The non-EU character of the EPC is significant, as it lacks the administrative coherence and judicial oversight mechanisms characteristic of the EU legal framework. This institutional fragmentation historically created difficulties for patent holders, who were often required to litigate in multiple jurisdictions in order to enforce their rights.⁵²⁴ As *Brinkhof* observes, this fragmentation contributed to the emergence of a “market

⁵¹⁸ USPTO, ‘General Information Concerning Patents’ <http://www.uspto.gov/web/offices/pac/doc/general/index.html#laws>.

⁵¹⁹ Aurora Plomer, ‘The Unified Patent Court and the Transformation of the European Patent System’ (2020) *IIC* 791.

⁵²⁰ European Patent Convention (adopted 5 October 1973, entered into force 7 October 1977, last revised 29 November 2000).

⁵²¹ The European Union has made specific interventions in patent law, particularly through the introduction of supplementary protection certificates for medicinal and plant protection products, regulated by Regulations (EC) No 469/2009 and No 1610/96. Additionally, the EU has established legal protections for biotechnological inventions through Directive 98/44/EC. These measures represent exceptions in the EU's approach to patent law, reflecting its targeted involvement in specific areas of intellectual property rights (see: Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 86).

⁵²² EPO, ‘Member states of the European Patent Organisation’ (EPO, 2024) <https://www.epo.org/about-us/foundation/member-states.html>.

⁵²³ Article 64 EPC.

⁵²⁴ Douwe de Lange, ‘EU Patent Harmonization Policy: Reconsidering the Consequences of the UPCA’ (2021) 16(10) *JIPPL* 1078.

of patents”, disproportionately favouring well-resourced corporate actors and contributing to competitive imbalances in the internal market.⁵²⁵

To address these inefficiencies, the Unified Patent Court (UPC), operational as of June 2023, which offers a centralised litigation forum for European patents, including those with unitary effect, was introduced. The UPC aims to harmonise enforcement, reduce litigation costs, and enhance legal certainty for patent holders and third parties alike. Its establishment represents a significant shift towards greater integration of patent enforcement within the EU’s institutional framework.

The focus of this work is the EPC which at least to some extent harmonised patent legislation in Europe.⁵²⁶ Given the importance of national patent statutes and courts for the interpretation of the law, references to national courts are made throughout this thesis. Still, since the substantive provisions of the EPC were drafted in accordance with the legal frameworks of the Member States at the time of drafting, and since all Member States of the EU have implemented the EPC, the patentability criteria laid down in national law are largely the same in most EPC Member States.⁵²⁷

b) The European Patent Convention and the European Patent Office

A uniform system for granting patents is provided by the EPC, an international convention which was ratified in 1973 in Munich, came into effect on 1 June 1978 and has since undergone numerous amendments, lastly in 2000, thus before the rapid advancement of AI technology. The EPO, which is in charge of reviewing patent applications and awarding patents, also manages the EPC.⁵²⁸ All EU Member States as well as a handful of non-EU nations, including Switzerland, Norway, United Kingdom, and Turkey, are part of the 39 contracting states that constitute the EPC, which creates a legislative framework for the awarding of patents that is highly harmonised throughout these governments.⁵²⁹ The EPC outlines the criteria for being granted a patent, the process for submitting and reviewing patent applications, and the responsibilities and rights of patent owners.

The inventor therefore obtains a European patent, where only one application is needed and most importantly only one examination procedure is taking place at the EPO in Munich, established by the Convention. There is also just a single regulation on the requirements of

⁵²⁵ Jan J Brinkhof, ‘The European Challenge. On Judicial Reasoning and on Legal Research and Teaching’ in D van Engelen (ed), *The European Challenge in On the Brink of European Patent Law* (Eleven International Publishing 2011) 127.

⁵²⁶ Ansgar Ohly, ‘Introduction: The Quest for Common Principles of European Intellectual Property Law – Useful, Futile, Dangerous?’ in Ansgar Ohly (ed), *Common Principles of European Intellectual Property Law* (Tübingen 2012) 3; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 18.

⁵²⁷ Annette Kur, Thomas Dreier and Stefan Luginbühl, *European Intellectual Property Law: Text, Cases and Materials*, 2nd edn (Edward Elgar 2019) 154; Christopher Wadlow, ‘Strasbourg, the Forgotten Patent Convention, and the Origins of the European Patents Jurisdiction’ (2010) *IIC* 123.

⁵²⁸ Article 4 and Articles 90-89 EPC.

⁵²⁹ EPO, ‘Member States of the European Patent Organisation’, www.epo.org/about-us/foundation/member-states.html.

patentability and the patenting process. Once a European patent is granted, it effectively transforms into a collection of national patents in the designated EPC Member States. While Article 69 EPC and its Protocol on Interpretation harmonize the scope of protection and interpretation across these countries, some elements of patent enforcement, validity disputes, and post-grant procedures remain governed by the individual laws and regulations of each Member State. First, the Opposition Division oversees the EPC's objection system, which was established to revoke European patents within nine months of their grant.⁵³⁰ Second, the Boards of Appeal (BoA) will hear appeals of the Opposition Division's decisions.⁵³¹ Finally, national courts may hear invalidity cases after the opposition time has passed, and only national courts may hear infringement proceedings.

Despite jurisdictions, as for example United Kingdom, Germany, and France, sharing the same legal foundation and following the EPO's decision-making practices since implementing the standardised patentability requirements set forth by the EPC in 1973, they sometimes have different approaches to applying these requirements.⁵³² Still, in all these approaches, the definition of "invention" is narrowed down to a mere technical feature (in the case of the EPO and France), a technical field (in Germany), or a technical contribution (in the United Kingdom).⁵³³ In this system, there are two significant factors that contribute to the "soft" harmonization between Member States of the EPC. These are the case law established by the BoA and Enlarged Board of Appeal (EBA), and the EPO Guidelines.⁵³⁴

The BoA is the first and final judicial body in EPO operations. It is responsible for evaluating disputes regarding first-instance judgments.⁵³⁵ If necessary, the BoA may refer matters to the EBA to ensure uniform application of the law.⁵³⁶ The EBA is higher in the hierarchy and its decisions are only legally binding on the BoA that referred the matter.⁵³⁷ The Rules of Procedure of the BoA state, however, that if a Board considers it essential to depart from a construction or explanation of the Convention contained in a previous opinion or decision of the EBA, the subject shall be addressed to the EBA.⁵³⁸ The established case law is often followed in the Member States of the EPC, even though decisions by the EBA and BoA are not legally binding on national courts (with the exception of the specific European patents in question).⁵³⁹

⁵³⁰ EPO, 'Opposition procedure' (2023) <https://www.epo.org/en/applying/european/oppositions>.

⁵³¹ Articles 99-112a EPC.

⁵³² The settled jurisprudence of the EPO on the interpretation of the EPC should normally be followed (*Actavis Group PTC Ehf and others v ICOS Corporation and another* [2019] UKSC 15 [56]).

⁵³³ Eva Stanková, 'Human Inventorship in European Patent Law' (2021) 80 *The Cambridge Law Journal* 11.

⁵³⁴ Tommaso G Trabucco, 'The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person' (LLM Thesis, MIPLC 2021) 12.

⁵³⁵ The EPO regularly releases a complete collection of decisions made by the Board of Appeal (referred to as "BoA Case Law"). The most recent volume was published in July 2022 (with selected sections revised in June 2024) and is available for viewing on the EPO website: <https://www.epo.org/law-practice/legal-texts/html/caselaw/2022/e/index.htm>.

⁵³⁶ Article 112(1) EPC.

⁵³⁷ Article 112(3) EPC.

⁵³⁸ Article 21 Rules of Procedure of the BoA (EPO).

⁵³⁹ Richard Arnold, 'Harmonization of European Patent Law' (2019) 14(9) *JIPLP* 657.

The EPO Guidelines,⁵⁴⁰ which serve as generic instructions for examiners and formalities officers, as well as a basis for patent practitioners to explain the law and practice before the EPO, are not legally binding. The EPC, including the Implementing Regulations and Protocols, as well as rulings by the BoA and EBA, must be relied upon for authoritative guidance on EPO practice. Although the EPO Guidelines are not legally enforceable, examiners are still expected to abide by them, and they are generally followed. The Guidelines are also frequently cited as a useful source of interpretation in national court rulings of EPC Member States.⁵⁴¹

c) The Unitary Patent Package

The creation of an autonomous and unitary patent valid throughout the now EU was first attempted in the Community Patent Convention (1975, Luxembourg) but ultimately failed, because some Member States did not ratify it. The deadlock was overcome in 2011, when Community bodies authorised “enhanced cooperation in the area of the creation of unitary patent”, amongst the Member States that have since then ratified the Agreement on a Unified Patent Court.⁵⁴² 25 EU Member States set up the new patent system, Regulation (EU) No 1257/2012, the so called “Unitary Patent Regulation” implementing enhanced cooperation in the area of the creation of unitary patent protection governed by the beforementioned regulation on the language aspects of applications and by an Agreement for the creation of a single court on patents.⁵⁴³ Moreover, Regulation (EU) No 1260/2012, the “Translation Regulation”,⁵⁴⁴ and the Agreement on a Unified Patent Court, were signed.⁵⁴⁵ The so-called “Unitary patent package” entered in force on 1 June 2023.

The European Unitary Patent is granted by the EPO in Munich itself and makes it possible to get patent protection in all participating EU Member States by submitting a single request. The Unitary Patent has a supranational, unitary and autonomous character. It can only be granted for all participating EU Member States and provides uniform protection in all countries, according to the rules set out in the Unitary Patent Regulation and the Translation Regulation.⁵⁴⁶ The Unitary Patent Regulation facilitates a unified patent system covering all participating EU states, alongside traditional European and national patents. Conversely, the Translation Regulation simplifies language requirements for unitary patents, aiming to cut translation costs and administrative burdens across multiple EPC Member States.⁵⁴⁷

⁵⁴⁰ The April 2025 edition of the EPO Guidelines are accessible at: <https://www.epo.org/en/legal/guidelines-epc>.

⁵⁴¹ Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 406; Cesare Galli and Mariangela Bogni, ‘Il requisito di brevettabilità dell’attività inventiva’, in C Galli and A Gambino (eds), *Codice Commentato della Proprietà Industriale ed Intellettuale* (UTET, Turin 2011) 578; Mario Franzosi, ‘Non ovvietà’ in *Studi di diritto industriale in onore di Adriano Vanzetti* (Giuffrè 2004) 474.

⁵⁴² Regulation (EU) No 1257/2012 of the European Parliament and of the Council of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection [2012] OJ L361/1.

⁵⁴³ Ibid.

⁵⁴⁴ Council Regulation (EU) No 1260/2012 of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection with regard to the applicable translation arrangements [2012] OJ L361/89.

⁵⁴⁵ EUR-Lex, ‘Unitary Patent’ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3A126056>.

⁵⁴⁶ For a more detailed analysis see: Christoph Keussen, ‘Articles 1-6 Translation Regulation’ in W Tilmann and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (OUP 2018) 277 et seq.

⁵⁴⁷ Ibid.

Disputes are devolved to the Unified Patent Court (UPC),⁵⁴⁸ that handles unitary and traditional European patent infringement and validity issues among EU Member States. Despite being bound by EU law and the Court of Justice of the European Union, the UPC operates independently from the EU *acquis*.⁵⁴⁹ Exclusive jurisdiction over unitary patents is granted to the UPC, with a 7-year transitional period (potentially extendable to 14) allowing patent owners to opt out traditional patents for national court litigation.⁵⁵⁰ The UPC aims to streamline European patent law, tackling fragmentation and inconsistencies to promote innovation. However, its non-EU *acquis* status complicates its relationship with the EU and the EPO.⁵⁵¹

The initial participation of 17 (now 18, after Romania acceded later) out of 27 EU Member States, along with a lack of substantive patentability harmonization and a significant number of opt-outs registered, suggest that the harmonizing impact of the UPC may be delayed.⁵⁵² Still, up until now, the UPC has already established an independent approach to claim construction and assessment of inventive step⁵⁵³ that diverges significantly from the practices of the EPO.⁵⁵⁴ This divergence affects not only how patents are interpreted and enforced, but also establishes new procedural standards across Europe.⁵⁵⁵

⁵⁴⁸ Article 32 of the Agreement on a Unified Patent Court (UPCA) sets out the powers of the UPC: These powers cover various actions such as infringement and damages claims, challenges to the validity of patents, requests for declarations of non-infringement, and requests for interim measures and injunctions. In particular, the UPC does not have the power to adjudicate on matters relating to ownership of a European patent application or a European patent, as provided for in Article 32(2) of the UPCA and Article 61 EPC. Disputes relating to ownership remain within the jurisdiction of national courts. (Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 84).

⁵⁴⁹ Winfried Tilmann, ‘Articles 20 and 21 UPCA’ in W Tilmann and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (OUP 2018) 440-458; Douwe de Lange, ‘EU Patent Harmonization Policy: Reconsidering the Consequences of the UPCA’ (2021) 16(10) *JIPLP* 1078.

⁵⁵⁰ EPO, ‘Agreement on a Unified Patent Court (UPC Agreement)’, art 83 https://www.epo.org/en/legal/upc-upc/2022/upca_83.html.

⁵⁵¹ Winfried Tilmann, ‘Introduction to this Commentary’ in W Tilmann and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (OUP 2018) 19.

⁵⁵² Kluwer Patent Blog, ‘Unified Patent Court: 465,247 Opt-Outs in the Sunrise Period’ (7 June 2023) <https://patentblog.kluweriplaw.com/2023/06/07/unified-patent-court-465-247-opt-outs-in-the-sunrise-period/>; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 85.

⁵⁵³ On the topic see for example: Jens Pilger, ‘The UPC’s Approach to Assess Inventive Step – A New Approach Reflecting the German Practice?’ (JUVE Patent, 27 January 2025) <https://www.juve-patent.com/news-and-stories/legal-commentary/the-upcs-approach-to-assess-inventive-step-a-new-approach-reflecting-the-german-practice>; Aloys Hüttermann, ‘Inventive step at the UPC – much ado about nothing (new)?’ (Kluwer Patent Blog, 3 June 2025) <https://legalblogs.wolterskluwer.com/patent-blog/inventive-step-at-the-upc-much-ado-about-nothing-new>.

⁵⁵⁴ Mathias Karlhuber, ‘Das Einheitliche Patentgericht – ein Erfolg? Eine Einführung und Zwischenbilanz nach knapp zwei Jahren Praxis’ (ICC Germany, 5 June 2025) <https://www.iccgermany.de/magazin-post/das-einheitliche-patentgericht-ein-erfolg>.

⁵⁵⁵ For a detailed analysis of the UPC case law see, amongst others: Axel Metzger, ‘Ein Jahr Rechtsprechung des EPG - Welche einheitliche Praxis entsteht?’ (2024) *GRUR* 715; Matthias Leistner, ‘Injunctive Relief in the UPC – A Case for Carefully Limited Flexibility’ in F Thouvenin (ed), *Kreation Innovation Märkte – Creation Innovation Markets: Festschrift für Reto M Hilty* (Berlin and Heidelberg 2023) 619-636.

4. Approaches to AI

a) International Context

According to a WIPO study over 340.000 AI-related patent applications have been filed and over 1.6 million scientific articles on AI have been published since AI first emerged in the 1950s.⁵⁵⁶ A figure that, in perspective, means more applications and products related to this technology have already or will reach the market in the near future.⁵⁵⁷ The sectors that dominate are transport, telecommunications, medical and life sciences, and the segment that includes personal devices, computers, and systems for human-computer interaction.⁵⁵⁸ Consistent with a WIPO patent landscape report on generative AI of 2024, over the last decade, the number of patent families in generative AI has increased dramatically from 733 in 2014 to over 14.000 in 2023.⁵⁵⁹

When it comes to AI, a key issue that remains the subject of considerable debate is how AI should be regulated, particularly in contexts intersecting with patent law. While technology companies claim to support regulation, they often prioritise rapid commercialisation of AI products, sometimes at the expense of thorough risk assessment or normative alignment.⁵⁶⁰ At the same time, legislative bodies struggle to design timely and effective regulations that can accommodate the rapid evolution of AI technologies. This regulatory lag is especially pronounced in domains where legal protection and innovation intersect, such as patent law.

As Advocate General Giuseppe Tesauro noted in his 1995 conclusions on the unrelated case C-13/94, “law cannot isolate itself from social reality and cannot fail to adapt to it as quickly as possible. Otherwise, there is a risk of imposing outdated views and thus assuming a static role. The law [...], must instead adapt to social evolution, must therefore be able to regulate new situations as brought to light by that evolution and by scientific progress itself”.⁵⁶¹ This is as true today as it was in 1995, even in patent law, where AI-related inventions are increasingly challenging conventional concepts of inventorship, novelty, and disclosure in patent law. As AI continues to spread across various industries, the pace of technological development outstrips

⁵⁵⁶ WIPO, *WIPO Technology Trends 2019: Assistive Technology* (WIPO 2019); for an updated version see also: WIPO, *WIPO Technology Trends 2021: Assistive Technology* (WIPO 2021).

⁵⁵⁷ Daniel F Spulber, ‘How Patents Provide the Foundation of the Market for Inventions’ (2014) 11(2) *Journal of Competition Law & Economics* 293.

⁵⁵⁸ WIPO, *WIPO Technology Trends 2019: Assistive Technology* (2019); for an updated version see also: WIPO, *WIPO Technology Trends 2021: Assistive Technology* (2021); on the matter see also: Hidemichi Fujii and Shunsuke Managi, ‘Trends and Priority Shifts in Artificial Intelligence Technology Invention: A global patent analysis’ (2017) *Economic Analysis and Policy, Elsevier* 60.

⁵⁵⁹ WIPO, ‘Global Patenting and Research in Generative Artificial Intelligence’ (Patent Landscape Report on Generative Artificial Intelligence) <https://www.wipo.int/web-publications/patent-landscape-report-generative-artificial-intelligence-genai/en/2-global-patenting-and-research-in-genai.html>.

⁵⁶⁰ Melissa Heikkilä, ‘Generative AI Risks Concentrating Big Tech’s Power: Here’s How to Stop It’ (MIT Technology Review, 18 April 2023) <https://www.technologyreview.com/2023/04/18/1071727/generative-ai-risks-concentrating-big-techs-power-heres-how-to-stop-it/>.

⁵⁶¹ European Court of Justice, *Opinion of Advocate General La Pergola* (19 January 1995) Case C-13/94, CELEX:61994CC0013 <https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:61994CC0013&from=NL>.

the pace at which laws can be created or updated to regulate it, growing the need for legal expertise in this area.⁵⁶²

Given the growing realisation of AI's transformative potential and its legal and ethical risks, scholars and practitioners have proposed the establishment of a dedicated international regulatory body, likened to a "CERN for AI". Such an institution could play a critical role in standardising global governance frameworks, facilitating cross-border data and patent harmonisation, and overseeing ethical compliance.⁵⁶³ Comparable to nuclear non-proliferation models, it could also establish independent audit mechanisms to assess the safety and societal impact of AI technologies, filling governance gaps not addressed by national patent offices or regional patent organisations.

In the meantime, since 2018, the five largest intellectual property offices globally, namely the EPO, the Japan Patent Office, the Korean Intellectual Property Office, the China National Intellectual Property Administration, and the United States Patent and Trademark Office, collectively referred to as the "IP5", which are responsible for processing over 80% of patent applications filed worldwide, have been working towards a unified approach to address the challenges posed by global technological innovation.⁵⁶⁴ In 2019, the IP5 offices formalised their cooperation in relation to emerging technologies and AI by establishing a dedicated task force. This interdisciplinary body, which includes participation from the WIPO, has been tasked with examining the legal, technical, and policy implications of novel technologies and AI. It also assesses the effects of these technologies on both substantive patent law and administrative processes within the five offices. The primary objective of the task force is to identify areas where coordinated action by the IP5 would be most beneficial. These include, inter alia, the deployment of AI-based tools to assist patent examiners and enhance the efficiency of the patent granting process, the interpretation and application of patentability criteria to AI-related inventions, and the procedural treatment of applications relating to inventions autonomously generated by AI systems (see more on this in Section G.I.4).⁵⁶⁵

⁵⁶² For a more detailed discussion on the legal protection of innovative technologies see, for example: Hanns Ullrich, 'Legal Protection of Innovative Technologies: Property or Policy?' in O Granstrand (ed), *Economics, Law and Intellectual Property* (Berlin and Heidelberg 2003) 439 et seq.; Mark Fenwick, Wulf Kaal and Erik P M Vermeulen, 'Regulation Tomorrow: What Happens When Technology is Faster than the Law' (2017) 6 *American Business Law Review* 561, 567–568 https://infojustice.org/wp-content/uploads/2018/11/Computer-Generated-Inventions-v2_McLaughlin.pdf.

⁵⁶³ Ljubisa Bojic et al., 'CERN for AGI: A Theoretical Framework for Autonomous Simulation-Based Artificial Intelligence Testing and Alignment' (2023) arXiv:2312.09402 [cs.CY] 25 <https://arxiv.org/abs/2312.09402>; Gary Marcus, 'A CERN for AI and the Global Governance of AI' (Substack, 26 October 2023) <https://garymarcus.substack.com/p/a-cern-for-ai-and-the-global-governance>; David Matthews and Martin Greenacre, 'EU science advisers back call for a "CERN for AI" to aid research' (Science Business, 15 April 2024) <https://sciencebusiness.net/news/ai/eu-science-advisers-back-call-cern-ai-aid-research>.

⁵⁶⁴ European Patent Office, 'Artificial intelligence' (Innovation and patenting in focus, 2025) <https://www.epo.org/en/news-events/in-focus/ict/artificial-intelligence>.

⁵⁶⁵ Ibid.

b) United States

Generally speaking, the United States have taken a “soft” approach by applying existing regulations to AI systems rather than enacting *sui generis* legislation.⁵⁶⁶ The United States remain the leading international AI and technology market, thanks to academic excellence and substantial investments in the field.⁵⁶⁷ To this day, the United States is the ultimate world leader when it comes to the digital market: no other place in the world has such a concentration of high-tech companies as the Silicon Valley.⁵⁶⁸ Every major technological advancement in recent years has emerged from there. The United States economy has increasingly relied on digital market giants such as the “GAFAM” companies (Google, Apple, Facebook, Amazon, and Microsoft).⁵⁶⁹ The National AI Research Resource Task Force, established under the Biden Administration, reflects an effort to enhance access to AI research infrastructure, potentially accelerating patentable output, while maintaining the market-driven model that has characterised Silicon Valley’s dominance in digital innovation.⁵⁷⁰ Despite this, the US National Security Commission on AI has stressed the urgency of increased federal investment in AI research, underscoring concerns about economic competitiveness and the future of technological leadership.⁵⁷¹

In the context of patents, this regulatory minimalism permits flexible judicial interpretation under existing statutes, such as Title 35 USC. Under 35 USC §103, an invention is only patentable if it would not be obvious to someone with “ordinary skill in the relevant field”. Courts continue to assess obviousness dynamically, taking into account factors such as the skill level required, the scope and content of the prior art, and whether the claimed invention would have been “obvious to try”.⁵⁷² AI-related inventions currently fall into a legal grey area, since US patent law does not recognise non-human inventors. Still, the suggestions in this work on the inventive step can similarly be applied in the United States. The prevailing reliance on doctrines such as product liability, data privacy, and traditional intellectual property contributes to a patchwork of guidance, with significant implications for inventorship attribution and patentability requirements.

⁵⁶⁶ Louis Lehot, ‘Artificial Intelligence Comparative Guide’ (Mondaq, 9 August 2024) <https://www.mondaq.com/unitedstates/technology/1059776/artificial-intelligence-comparative-guide#:~:text=Despite%20AI's%20ubiquity%20across%20every,regulate%20certain%20aspects%20of%20AI>.

⁵⁶⁷ Kurt Conrad and Stephen Chambliss, ‘The Digital Crossroads: US Leadership at Stake in the Global Trade Arena’ (The Hill, 2024) <https://thehill.com/opinion/4490251-the-digital-crossroads-us-leadership-at-stake-in-the-global-trade-arena/>.

⁵⁶⁸ Ibid.

⁵⁶⁹ National Foreign Trade Council (NFTC), ‘Digital Trade Leadership’ <https://www.nftc.org/digital-trade-leadership/>.

⁵⁷⁰ The White House, ‘The Biden Administration Launches the National Artificial Intelligence Research Resource Task Force’ (10 June 2021) <https://www.whitehouse.gov/ostp/news-updates/2021/06/10/the-biden-administration-launches-the-national-artificial-intelligence-research-resource-task-force/>; ‘National Artificial Intelligence Research Resource Task Force’ (AI.gov) <https://www.ai.gov/nairrtf/>.

⁵⁷¹ National Security Commission on Artificial Intelligence, *Final Report* (March 2021) <https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf>.

⁵⁷² For a more detailed analysis on AI-related inventions in the US see, amongst others: Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1453 et seq.

c) European Union

The European Union has generally speaking taken a more comprehensive and formalised regulatory approach when it comes to AI.⁵⁷³ A series of legislative initiatives, including the Data Governance Act, the Data Act, the Digital Services Act, and the Digital Markets Act, form the broader data and digital policy architecture within which the AI Act is situated.⁵⁷⁴ The EU AI Act introduces a risk-based classification system that differentiates between prohibited, high-risk, and low-risk AI applications.⁵⁷⁵ Although the Act is not specific to intellectual property, its provisions indirectly affect patent law by shaping the environment in which AI technologies are developed and disclosed.⁵⁷⁶ For example, high-risk applications such as algorithmic CV screening tools may be subject to rigorous transparency and accountability obligations, potentially influencing the patentability of such systems under the requirement for sufficient disclosure.⁵⁷⁷ Moreover, Europe's commitment to trustworthy AI aligns with its broader legal culture, which favours precautionary regulation and public oversight.⁵⁷⁸ The European Commission has sought to address concerns over talent outflow by increasing investment through the Digital Europe and Horizon Europe programmes, aiming to foster a more conducive environment for innovation and patent generation within the EU.

In its resolution of 20 October 2020, the European Parliament addressed intellectual property rights in the context of AI technology development.⁵⁷⁹ Shortly thereafter, on 25 November

⁵⁷³ European Commission, 'Europe fit for the Digital Age: Commission proposes new rules and actions for excellence and trust in Artificial Intelligence' (Press Release, 21 April 2021) https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1682; European Commission, 'European Approach to Artificial Intelligence' (Digital Strategy, 21 April 2021) <https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence>.

⁵⁷⁴ Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act) [2022] OJ L152/1; Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act) [2023] OJ L2023/2854; Regulation (EU) 2022/2065 of the European Parliament and of the Council of 19 October 2022 on a Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act) [2022] OJ L277/1; Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act) [2022] OJ L265/1; for a more in-depth analysis on this triad see Matthias Leistner, 'The Commission's Digital Markets and Services Package – New Rules for Big Tech and Big Data' (2021) *GRUR International* 515 et seq., <https://doi.org/10.1093/grurint/ikab039>.

⁵⁷⁵ Regulation (EU) 2024/1689; see also: 'EU AI Act: First Regulation on Artificial Intelligence' (European Parliament, 1 June 2023) <https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence>.

⁵⁷⁶ Paolo Brambilla, 'Che cos'è l'Artificial Intelligence Act in Europa?' (La mia finanza, 7 April 2023) <https://www.lamiafinanza.it/2023/04/che-cose-lartificial-intelligence-act-in-europa/>.

⁵⁷⁷ For more on the approach of the AI Act see: Mauritz Kop, 'EU Artificial Intelligence Act: The European Approach to AI' (2021) *Stanford - Vienna Transatlantic Technology Law Forum, Transatlantic Antitrust and IPR Developments* 1 et seq.

⁵⁷⁸ Before that, on 9 March 2018, the Commission announced its plan to establish a High-Level Expert Group on AI. The group's mission was to: (a) advise on forming a European Alliance for AI by harmonizing diverse stakeholder interests; (b) support European AI initiatives; and (c) develop ethical guidelines for AI based on the European Group on Ethics and New Technologies' recommendations. In 2019, the "Ethics Guidelines for Trustworthy AI" were published, outlining three core requirements: AI must comply with laws, adhere to ethical principles, and be reliable both technically and socially to avoid unintended harm (European Commission, 'Artificial Intelligence: Commission kicks off work on marrying cutting-edge technology and ethical standards' (Press Release, 8 March 2018) https://ec.europa.eu/commission/presscorner/detail/en/IP_18_1381).

⁵⁷⁹ European Commission, 'Making the most of the EU's innovative potential: An intellectual property action plan to support the EU's recovery and resilience' COM (2020) 760 final (Brussels, 25 November 2020).

2020, the European Commission released a study it had commissioned to explore the implications of AI for the European IP framework.⁵⁸⁰ This study was conducted by researchers from the Institute for Information Law and the Joint Institute for Innovation Policy and investigated the current landscape of copyright and patent law in Europe with respect to outputs generated by or with the assistance of AI systems.⁵⁸¹ With regard to European patent law, and specifically the EPC, the study analysed a series of legal challenges associated with AI-related outputs. These include issues of inventorship and ownership, as well as the criteria for novelty, inventive step, and sufficiency of disclosure. The authors conclude that the EPC, in its current form, is generally adequate to address the challenges posed by AI-related inventions.⁵⁸² In terms of novelty assessment, the study suggests that both national intellectual property offices and the EPO should ensure they have AI capabilities that are comparable to those accessible to advanced patent applicants. For the inventive step requirement, revisions to the EPO's Examination Guidelines were warranted to reflect changes in the concept of the "person skilled in the art" and to accommodate the influence of AI on secondary indicia. Regarding sufficiency of disclosure, the introduction of a deposit system for relevant AI algorithms, training data, and models was identified as a potentially beneficial measure. For other identified concerns, the study advised a cautious approach, recommending that regulatory action be deferred until such issues are concretely raised in case law. Finally, it called for further research into alternative intellectual property regimes, such as trade secret protection, unfair competition law, and contractual arrangements, as potential mechanisms for protecting AI-assisted outputs.⁵⁸³

d) EPO

Neither the EPC nor its Implementing Regulations make explicit mention to AI or machine learning. Still, recently the EPO has adapted its approach in the Guidelines to reflect the increasing prominence of AI in patent filings.⁵⁸⁴ As a result, the EPC framework allows the EPO to grant patents in a wide spectrum of technological areas in which AI is applied to solve technical problems.

This has been made necessary, given the rise in AI-related patents. As of 2022, 786 European patents were granted for AI-related inventions, marking an increase from 683 in 2021 and 433 in 2020.⁵⁸⁵ This trend demonstrates growing recognition of AI technologies within the patent system, although the pace of growth appears to be moderating. Despite this growth, the grant

⁵⁸⁰ Hartmann C, Allan J, Hugenholtz P B, Quintais J P et al., *Trends and developments in artificial intelligence – Challenges to the intellectual property rights framework - Final report* (Publications Office of the EU 2020) <https://data.europa.eu/doi/10.2759/683128>.

⁵⁸¹ Bernt Hugenholtz, João P Quintais and Daniel Gervais, '[Guest Post] Study on Trends and Developments in Artificial Intelligence: Challenges to the IPR Framework' (The IPKat, 9 December 2020) <https://ipkitten.blogspot.com/2020/12/guest-post-study-on-trends-and.html>.

⁵⁸² Ibid.

⁵⁸³ Ibid.

⁵⁸⁴ EPO, 'Artificial intelligence' (Innovation and patenting in focus) <https://www.epo.org/en/news-events/in-focus/ict/artificial-intelligence>.

⁵⁸⁵ Connor Crickmore, 'Year in Review: Artificial Intelligence at the EPO in 2022' (Reddie & Grose, 7 February 2023) <https://www.reddie.co.uk/2023/02/07/year-in-review-artificial-intelligence-at-the-epo-in-2022/>; EPO, 'Insight into Artificial Intelligence' (Patent Index 2023) <https://www.epo.org/en/about-us/statistics/patent-index-2023/insight-artificial-intelligence>; EPO, *Annual Report 2022* (EPO 2023).

rate for AI-related applications still remains below the overall average grant rate at the EPO.⁵⁸⁶ This discrepancy is largely attributable to the inherent challenges of patenting AI technologies, especially the difficulty in demonstrating technical character and inventive step for inventions.

In addition to its internal policy development, the EPO maintains dialogue with external stakeholders, including legal professionals and national intellectual property offices, regarding AI and its intersection with patent law.⁵⁸⁷ This consultation process informs annual updates to the EPO Guidelines and aligns with broader harmonisation efforts.⁵⁸⁸

To advance the internal use of AI, the EPO formed a dedicated Data Science team in 2019.⁵⁸⁹ This team, composed of six core data scientists supported by technically specialised patent examiners from Directorate-General 1, aims to enhance the efficiency and quality of the patent granting process through the application of AI and machine learning tools. The team's activities are concentrated in three primary domains: natural language processing, computer vision, and automated translation. These AI applications are integrated into key patent processing tasks such as document classification, prior art searching, and translation of technical disclosures.⁵⁹⁰

The EPO's AI systems employ cutting-edge deep learning architectures, which are adapted to address the unique challenges of the patent domain. The language models in use are trained on extensive datasets drawn from the EPO's prior art collections and are fine-tuned to interpret complex technical terminology and syntactic structures characteristic of patent literature. Presently, the EPO relies predominantly on supervised learning techniques, with models being trained on annotated data reflecting the expertise of its examiners.

5. Preliminary Results

The current international patent framework is shaped by multiple treaties and national regulations, with the WIPO playing a central role. WIPO, a specialized UN agency founded in 1967, administers various treaties that guide patent protection across 193 Member States. It does not issue patents itself but facilitates international patent protection through agreements such as the Paris Convention and the Patent Cooperation Treaty. The Paris Convention grants inventors a 12-month priority window to file patents in Member States based on the first filing date, while the Patent Cooperation Treaty simplifies the process for applicants seeking protection in multiple countries. Additionally, the Agreement on TRIPs, enacted in 1994 under the World Trade Organization, sets minimum standards for patent protection and emphasizes transparency in patent disclosure.

⁵⁸⁶ EPO, *Technology Trends 2023: Artificial Intelligence* (EPO 2023) <https://www.epo.org/en/news-events/in-focus/ict/artificial-intelligence.html>.

⁵⁸⁷ Frances Wilding, 'Google and Samsung Top the List of Applicants for AI-related Patents at the EPO' (IAM, 16 December 2021) <https://www.iam-media.com/article/google-and-samsung-top-the-list-of-applicants-ai-related-patents-the-epo>.

⁵⁸⁸ EPO, 'Insight into Artificial Intelligence' (Patent Index 2023) <https://www.epo.org/en/about-us/statistics/patent-index-2023/insight-artificial-intelligence>.

⁵⁸⁹ EPO, 'Artificial Intelligence', <https://www.epo.org/en/news-events/in-focus/ict/artificial-intelligence>.

⁵⁹⁰ Ibid.

In the United States, patents are governed exclusively by federal law, under Title 35 of the USC. The USPTO grants patents that give inventors the right to exclude others from making, using, or selling the invention within the US. The non-obviousness requirement under 35 USC § 103 is particularly relevant for patentability and corresponds to the EPC's Article 56, emphasizing the need for an inventive step.

The European patent system is primarily governed by the EPC, an international treaty signed in 1973, which established the EPO to oversee the patent application process. The EPO is not an EU institution, but a separate public international organization. Although European patents are granted centrally through the EPO, these patents effectively become a bundle of national patents enforceable in individual Member States. Harmonization in Europe is achieved through substantive provisions of the EPC, and decisions by the EPO's BoA are influential in shaping national interpretations, although they are not binding on national courts. Additionally, the EPO Guidelines serve as a key reference for patent examiners and practitioners.

A significant development in the European patent landscape is the introduction of the Unitary Patent Package, which entered into force on 1 June 2023. This package introduces the European Unitary Patent, providing uniform protection across participating EU Member States with a single application. Disputes over these patents are resolved by the Unified Patent Court, which aims to streamline patent enforcement across Europe. However, with a seven-year transition period and the ability for patentees to opt out of the UPC, the full harmonizing effect of the new system will take time to materialise.

In the field of AI, international bodies such as WIPO and the IP5 offices have acknowledged the increase in AI-related patents and the regulatory difficulties presented by AI inventions. While the United States take a flexible approach of applying existing laws, the EU is pursuing a more formal regulatory framework, including the AI Act, which indirectly influences patent law. Studies suggest that the EPC framework is generally adequate for AI inventions, but they also recommend updating the guidelines and considering alternative intellectual property protections.

III. Patentability Requirements under the EPC

According to the EPC, the criteria for patentability are: (a) patentable subject matter as defined in Article 52(1) EPC, taking into account the exclusions in Article 52(2)-(3) EPC; (b) novelty (Article 54 EPC); (c) inventive step (Article 56 EPC); and (d) industrial applicability (Article 57 EPC).⁵⁹¹

These ensure that the exclusive rights conferred by a patent are granted only for inventions that provide a genuine technical contribution to the state of the art.⁵⁹² Though not explicitly mentioned as a criterion in Article 52(1) EPC, the requirement of sufficient disclosure under

⁵⁹¹ EPO Guidelines 2025, Part G-I, 1.

⁵⁹² Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 79-80; Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 7.

Article 83 EPC also plays a critical role. The application must disclose the invention in a manner that enables a person skilled in the art to carry it out.

1. Patentable Subject Matter

Within the framework of the EPC, irrespective of the issue as to whether an AI-related invention can be protected under patent law, it must first be determined whether such an outcome qualifies as an “invention” within the meaning of Article 52 EPC.⁵⁹³ According to the EPC, a prerequisite for patentability is that the claimed subject matter qualifies as an “invention” within a technological domain. Consequently, items explicitly excluded, such as discoveries, scientific theories, or computer programs as such, do not meet this criterion. The invention must exhibit “technical character” and must contribute to the resolution of a technical problem.

a) The Notion of “Invention”

Although patents should be granted for “inventions”,⁵⁹⁴ a proper definition is missing in the *travaux préparatoires* of the EPC, since the Member States could not agree on one and wanted “to retain the flexibility necessary for the [patent] system”.⁵⁹⁵

An invention can be generally described as something that did not exist prior and therefore is not a discovery, that is already existing in nature and is a simple uncovering and disclosing of information about the natural world, including describing properties of an already-existing substance.⁵⁹⁶ The difference between a discovery and an invention is that the second entails a “spark” of human ingenuity, for example implementing a discovery into a reproducible process.⁵⁹⁷ In certain cases, such as with biotechnological inventions, specific human intervention, like isolating biological material from its natural surroundings or producing it synthetically, is necessary.⁵⁹⁸

⁵⁹³ Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für Geistiges Eigentum* 382.

⁵⁹⁴ For example see: Article 4bis of the Paris Convention (“Patents applied for in [...] the Union [...] shall be independent of patents obtained for the same invention in other countries”); Article 1 of the Patent Cooperation Treaty (the Contracting States “constitute a Union for cooperation in the filing, searching, and examination, of applications for the protection of inventions”); Article 27 of the TRIPS Agreement (“patents shall be available for any inventions, whether products or processes, in all fields of technology”); Article 52 EPC.

⁵⁹⁵ EPC Preparatory DOC BR/168/72 (15 March 1972) [26], as cited in Justine Pila, ‘The Future of the Requirement for an Invention: Inherent Patentability as a Pre- and Post-Patent Determinant’ in E Arezzo and G Ghidini (eds), *Biotechnology and Software Patent Law: A Comparative Review of New Developments* (Edward Elgar 2011) 68.

⁵⁹⁶ According to a Comparative Study of Substantive Law, which influenced the drafting of the EPC 1973 and its accompanying Community Patent Convention, a patent can only protect an invention (a creation) and not a discovery, which is defined as the mere observation of an existing reality. The study was conducted in 1953 under the auspices of the Council of Europe and is cited in Justine Pila, *The Requirement for an Invention in Patent Law* (OUP 2010) 174 et seq.

⁵⁹⁷ Sigrid Sterckx and Julian Cockbain, *Exclusions from Patentability: How Far Has the European Patent Office Eroded Boundaries* (Cambridge University Press 2012) 133.

⁵⁹⁸ Directive 98/44/EC of the European Parliament and of the Council of 6 July 1998 on the legal protection of biotechnological inventions [1998] OJ L213/13, art 3.

Given the absence of a definition, patent law practitioners are not restricted to a specific legislative interpretation of terms. However, when interpreting the concept of an invention, it is crucial to consider the current landscape of research and technological progress,⁵⁹⁹ and that its meaning and purpose mirror the intent of the specific regulation, making it “functionally determined”.⁶⁰⁰ The values underlying the regulation, aimed at balancing the interests involved as determined by the legislature, must be acknowledged.⁶⁰¹ This ambiguity aligns with the objective of patent law to foster technological advancement, at the same time, no law will be capable of accounting for all potential developments in advance posing the risk that a law attempting to comprehensively address all possibilities might, rather than achieving good, cause harm by restricting commercial development and legal application. Thus, it is essential to consider the current state of scientific knowledge when interpreting the inherently ambiguous and legislatively undefined concept of an invention.⁶⁰² This ensures flexibility and accommodates the dynamic and continuous nature of technological progress.⁶⁰³

A foundational definition of an “invention” that remains influential in European patent law was established by Germany’s Federal Court of Justice’s (BGH) “*Rote Taube*” decision of 1969, predating the 1973 EPC.⁶⁰⁴ According to this decision, an “invention” requires a “teaching of technical content” (*Lehre zum technischen Handeln*).⁶⁰⁵ The court elaborated that subject matter should not be treated as non-inventions if it uses controllable natural forces and phenomena to achieve a causal and perceivable result.⁶⁰⁶ Specifically, the decision stated that an invention is a teaching for methodical action using controllable natural forces to achieve a causally foreseeable result. The court clarified that “controllable natural forces” (“*beherrschbare Naturkräfte*”) include not only physical forces in the narrow sense but also all effects exerted by materials, forces, and forms of energy. This broad interpretation encompasses phenomena from biology, physics, and chemistry.⁶⁰⁷

The requirement of repeatability and reproducibility, implicit in the *Rote Taube* decision, was later adopted and refined by the EBA. One such case is G 1/08, in which the EBA was asked to consider whether a method of crossing and selecting plants escaped the exclusion of “essentially biological processes” under Article 53(b) EPC by containing an additional feature of a technical nature.⁶⁰⁸ In its response, the EBA made a general statement that the “essence of invention” is “human intervention in a process in order to bring about a desired result”.⁶⁰⁹ The EBA therefore interpreted the concept of invention as requiring “human intervention” or an intentional

⁵⁹⁹ EPO, T 489/14, 22 February 2019 (*Pedestrian simulation/CONNOR*), § 16.

⁶⁰⁰ Karl Larenz, *Methodenlehre der Rechtswissenschaft* (6th edn, Berlin and Heidelberg 1991) 482 et seq.

⁶⁰¹ *Ibid.*, 119 et seq.

⁶⁰² BGH, Judgment of 27 March 1969, X ZB 15/67 *Rote Taube* [1969] GRUR 672.

⁶⁰³ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 56 et seq.

⁶⁰⁴ BGH, Judgment of 27 March 1969, X ZB 15/67 *Rote Taube* [1969] GRUR 672; Margarete Singer and Dieter Stauder, ‘Article 52 EPC’ in M Singer and D Stauder (eds), *The European Patent Convention* (Vol I, Sweet & Maxwell 2003) [17].

⁶⁰⁵ *Ibid.*

⁶⁰⁶ BGH, Judgment of 27 March 1969, X ZB 15/67 *Rote Taube* [1969] GRUR 672; see also: Joseph Straus, ‘Biotechnologische Erfindungen - ihr Schutz und seine Grenzen’ (1992) GRUR 252 et seq.

⁶⁰⁷ Joseph Straus, ‘Biotechnologische Erfindungen - ihr Schutz und seine Grenzen’ (1992) GRUR 252 et seq.

⁶⁰⁸ EPO, G 1/08, 9 December 2010 (*Tomatoes/State of Israel*).

⁶⁰⁹ *Ibid.*

abstention therefrom. This decision has been cited as authoritative guidance on the concept of invention in subsequent cases. More recently, the EBA applied this approach in a decision on the patentability of a simulation method, which falls outside the biotechnology context. In this case, the EBA emphasized that the technicality of the invention “implies that an object is created, or a process is run with some purpose based on human creativity”.⁶¹⁰ Essentially, the case law of the EPO has embraced a formalistic interpretation of the technical character criterion. This interpretation essentially removes the necessity to scrutinise whether an invention exceeds the boundaries of Article 52 EPC, provided that the patent claims are formulated to incorporate any form of physicality or materiality.⁶¹¹

b) The Requirement of “Technical Character”

Although the EPC does not explicitly define “invention”, Article 52(2) EPC provides a non-exhaustive list of examples that represent abstract or intellectual activities that do not aim to produce a direct technical result, often referred to as “non-inventions” or “abstract subject matter”,⁶¹² including:

- (a) discoveries, scientific theories and mathematical methods;
- (b) aesthetic creations;
- (c) schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers;
- (d) presentations of information.⁶¹³

This paragraph lists categories of subject matter that cannot be patented, but an invention can still qualify for protection if it demonstrates “technical character”.⁶¹⁴ The question “what is an invention?” therefore turns into “what has technical character?” under the EPC and in the practice of the EPO.⁶¹⁵

When the EPO examines inventions, the issue of technical character (or “technicality”) is of primary importance.⁶¹⁶ An invention must offer a technical solution to a technical problem.

⁶¹⁰ EPO, G 1/19, 10 March 2021 (*Pedestrian simulation*).

⁶¹¹ Ralph Nack, ‘The “Technical Invention” Criterion’ in M Haedicke and H Timmann (eds), *Patent Law: A Handbook on European and German Patent Law* (Munich 2014) 73 [40]; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 104.

⁶¹² Article 52(3) EPC clarifies that the abstract subject matter listed in Article 52(2) EPC is excluded from patentability only if a European patent application or patent pertains to such subject matter “as such”. This means the exclusion should be interpreted narrowly, implying an implicit fourth condition: inventions that include non-abstract subject matter may still be patentable even if they also encompass abstract elements.

⁶¹³ Article 52(2) EPC.

⁶¹⁴ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 15 *The Cambridge Law Journal* 4; Jochen Ehlers et al., ‘European Patent Office’, in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 100.

⁶¹⁵ Riccardo Fruscalzo, ‘Il carattere tecnico dell’invenzione’ (PhD thesis, University of Parma 2013) 7 et seq <https://www.repository.unipr.it/handle/1889/2148>; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 103.

⁶¹⁶ Rainer Moufang, ‘A Critical Mind’ in C Godt and M Lamping (eds), *A Critical Mind* (Berlin and Heidelberg 2023) 480, https://doi.org/10.1007/978-3-662-65974-8_19.

Non-technical aspects may be included in a claim, provided that, although non-technical in isolation, they contribute, within the context of the invention, to achieving a technical effect that serves a technical purpose.⁶¹⁷ This, in turn, supports the technical character of the invention. Consequently, the burden is on the applicant to clearly specify the technical effect being claimed. In the context of AI-related inventions, this may be demonstrated by including verifiable parameters alongside a relevant and meaningful test within the application.⁶¹⁸

As a brief excursus, it is worth noting that, in practical terms, this requirement poses specific challenges for machine learning models and AI systems, therefore Category I-III inventions, which frequently rely on mathematical methods. Algorithmic models themselves do not qualify for patent protection under Article 52(2)(c).⁶¹⁹ This provision aims to ensure that such knowledge remains in the public domain, which would in this case mean fostering the development of other AI-based devices.⁶²⁰ To be eligible for patent protection in present-day, a machine learning algorithm or model must be incorporated into a computer program with a distinct technical purpose and a recognized industrial application, as outlined in the patent application.⁶²¹ While such models are not patentable per se, Part G-II, 3.3.1 of the Guidelines clarifies that “their use does not by itself render inventions related to AI or machine learning nonpatentable”.⁶²²

The EPO’s Guidelines (for example, G-II, 3.3 and 3.6) clarify that a technical character can be present where an invention solves a technical problem using technical means, even when implemented through AI or machine learning algorithms.⁶²³ In such scenarios, the computational models and algorithms on which the invention is based may contribute to the technical character of the claimed subject-matter, but only insofar as they are directed towards resolving a technical problem by technical means.⁶²⁴ This may be the case, for example, where the models or algorithms are employed within a specific field of technology, or where they are designed in view of a particular technical implementation, thereby demonstrating a concrete

⁶¹⁷ EPO Guidelines 2025, Part G-VII, 5.4.

⁶¹⁸ Stefan Luginbuehl, ‘Patent Protection of Inventions Involving Artificial Intelligence’ in N Bruun, G B Dinwoodie, M Levin and A Ohly (eds), *Transition and Coherence in Intellectual Property Law* (Cambridge University Press 2021) 191; Ana Ramalho, *Intellectual Property Protection for AI-generated Creations: Europe, United States, Australia and Japan* (Routledge 2022) 94 et seq.

⁶¹⁹ An algorithm is a defined set of instructions that guides the execution of a process. If an algorithm is implemented solely as a software program without any additional technical impact, it does not qualify for patent protection (Article 52(2)(c) EPC). Similarly, AI models, which essentially function as numerical computations, are also excluded from patentability if they are claimed as such.

⁶²⁰ Giulia Schneider and Niccolò Abriani, *Diritto delle imprese e intelligenza artificiale - Dalla Fintech alla Corptech* (Il Mulino 2021) 167 et seq.

⁶²¹ Therefore, the patenting of an AI algorithm or model is only possible when they are utilized within a specific technical context or use case as integral elements of an invention. The requirement for technical character mandates that the specific technical application, which imparts the crucial technical aspect, is explicitly stated in an independent claim. As a result, the scope of patent protection is limited to that application. By appropriately applying the exclusions from patentability in the case of AI-related inventions, it ensures that fundamental building blocks remain unrestricted and can be freely employed in the development of AI-based applications, without any constraints. (See: Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 17.

⁶²² EPO Guidelines 2025, Part G-II, 3.3.1.

⁶²³ EPO Guidelines 2025, Part G-II, 3.3 and 3.6.

⁶²⁴ Ibid.

technical effect that extends beyond a mere abstract mathematical contribution.⁶²⁵ Consequently, it does not fall within the exclusions from patentability set out in Article 52(2) and (3) EPC. This approach has been subject to both academic scrutiny⁶²⁶ and professional commentary,⁶²⁷ particularly in light of evolving jurisprudence such as G 1/19.⁶²⁸

c) Applicability to AI-Related Inventions

The question of patentability of inventions generated (with the help or autonomously) by AI is not directly addressed by the EPC or the Guidelines.⁶²⁹ In practice, however, such inventions are assessed within the established framework for patentability. According to the EPO's longstanding approach, only features that contribute to the technical character of an invention are considered relevant for the inventive step analysis under Article 56 EPC. This principle also governs AI-related inventions.

As for Categories IV-V, due to the core attributes inherent in every AI program, these systems have the capability to perform new tasks in a creative, autonomous, and unpredictable manner,

⁶²⁵ The BGH for example provides a definition of technicality, which involves purposeful actions utilizing controllable natural forces to achieve observable outcomes directly resulting from these forces, devoid of any human intellectual involvement. Essentially, it requires a deliberate application of applied physics. It is worth noting, however, that a computer diverges from the conventional definition of a machine; instead, its functionality relies on its software. It can be perceived as a "virtual machine" where the algorithm itself assumes the role of the machine. Consequently, this allows for the substitution of matter and energy with information. An increasing proportion of innovative endeavours are now centred on software development. This trend strongly supports the notion that software should be considered a technical product falling under the purview of patent law. (On the matter see: Ansgar Ohly, 'Software und Geschäftsmethoden im Patentrecht' (2001) *Computer und Recht* 810; Swen Kiesewetter-Köbinger, 'Über die Patentierung von Programmen für Datenverarbeitungsanlagen' (2001) *GRUR* 187; Axel Horns, 'Der Patentschutz für softwarebezogene Erfindungen im Verhältnis zur „Open Source“-Software' (2000) *Internet Zeitschrift für Recht und Informatik* 6; Bernd Lutterbeck et al., 'Sicherheit in der Informationstechnologie und Patentschutz für Software-Produkte – Ein Widerspruch? Kurzgutachten – Erstellt im Auftrag des Bundesministeriums für Wirtschaft und Technologie' (2000) 19).

⁶²⁶ Michael M Fischer, 'Revisiting G 1/19 Three Years Later: A Missed Opportunity?' (2025) *GRUR International* 48 et seq.

⁶²⁷ Rainer K Kuhn, 'Securing Software Patents through the EPO' (IAM Media 2021) <https://www.iam-media.com/global-guide/innovation-invention-yearbook/2021/article/securing-software-patents-through-the-epo>.

⁶²⁸ EPO, G 1/19, 10 March 2021 (*Pedestrian simulation*); for a recent analysis see: Michael M Fischer, 'Revisiting G 1/19 Three Years Later: A Missed Opportunity?' (2025) *GRUR International* 48 et seq.

⁶²⁹ In 2024, the USPTO introduced guidance and illustrative examples specifically addressing inventorship in AI-assisted inventions. This guidance aims to balance the encouragement of human creativity and investment in AI-related innovations with the need to avoid unnecessarily restricting future technological progress. It explicitly acknowledges the role of AI in the inventive process while emphasizing the importance of human contribution. Effective from 13 February 2024, the guidance clarifies that inventions developed with AI assistance are not automatically excluded from patentability. It instructs patent examiners and applicants on assessing whether the human input in such inventions is sufficiently substantial to warrant patent protection. Building upon the established principles of inventorship, the guidance outlines procedures for identifying the appropriate human inventor(s) in cases where AI systems contribute to the inventive process. Ultimately, it affirms that patent rights may be granted when a human has made a significant inventive contribution, even if AI tools were involved. (see: Patent and Trademark Office, 'Inventorship Guidance for AI-Assisted Inventions' (Federal Register- The Daily Journal of the United States Government, 13 February 2024) <https://www.federalregister.gov/documents/2024/02/13/2024-02968/inventorship-guidance-for-ai-assisted-inventions>; USPTO, 'USPTO Issues Inventorship Guidance and Examples for AI-Assisted Inventions' (USPTO, 12 February 2024) <https://www.uspto.gov/subscription-center/2024/uspto-issues-inventorship-guidance-and-examples-ai-assisted-inventions>).

often resulting in innovative inventions.⁶³⁰ The way an invention was made does not present an insurmountable barrier to obtaining patent protection for AI-related inventions.⁶³¹ For instance, an AI system using genetic algorithms might introduce random mutations, leading to unexpected outcomes as it seeks to find the optimal solution. The system can independently select the most promising results from a large pool of possibilities, refining its approach by discarding less favourable outcomes. By continuously iterating this process, the system eventually arrives at the best possible solution. Machine learning is particularly skilled at analysing vast amounts of data, such as images, videos, and sensory inputs, identifying patterns, and generating new data that fits within those patterns.⁶³²

Still, AI patent applications are unlikely to succeed if the claimed subject matter is described in overly abstract terms. Even if such inventions have potential for various applications, both technical and non-technical, their lack of connection to a specific technical application or adaptation to a particular computer implementation will be a significant drawback during the patentability assessment in EPO proceedings.⁶³³ Patent applications should clearly explain how the AI contributes to a technical effect or solves a technical problem.⁶³⁴ For example, showing that an AI system enhances medical diagnostics by analysing physiological data in a way that improves accuracy or efficiency may establish the required technical character and support patentability.⁶³⁵ Thus, AI-related inventions must satisfy the EPO's technicality requirement by having at least one technical feature and demonstrating that the distinguishing features contribute to a technical effect, solving a technical problem in a specific field of technology.⁶³⁶ A key challenge is identifying all technical features, particularly those that contribute to the technical character beyond the mere AI based execution.⁶³⁷ The aspects of the invention must therefore sufficiently impact the technical character.⁶³⁸

While the requirements constituting a technical solution to a technical problem based on technical considerations can be met by Categories IV-V inventions, what remains controversial is whether a human inventive contribution, in the sense of a mental, creative act, is required.⁶³⁹

⁶³⁰ Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 7.

⁶³¹ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 89 et seq.; Jochen Ehlers et al., 'European Patent Office', in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 100-102.

⁶³² Connor Shorten, 'Unsupervised Feature Learning' (Towards Data Science, 2 February 2021) <https://towardsdatascience.com/unsupervised-feature-learning-46a2fe399929>.

⁶³³ Ibid, 485-486.

⁶³⁴ Ichiro Nakayama, 'Patentability and PHOSITA in the AI Era – A Japanese Perspective' in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 107.

⁶³⁵ Igor Kononenko and Matjaž Kukar, *Machine Learning and Data Mining* (Woodhead Publishing 2007) 7.

⁶³⁶ Carpmals & Ransford, 'Patenting AI: Three Reasons Why Patent Applications for Applied AI Inventions Do Not Succeed at the EPO' (Carpmaels & Ransford, 5 April 2023) <https://www.carpmaels.com/patenting-ai-three-reasons-why-patent-applications-for-applied-ai-inventions-do-not-succeed-at-the-epo/>.

⁶³⁷ Andreas Engel, 'Erfinderische Tätigkeit und Künstliche Intelligenz' (2022) *GRUR* 864.

⁶³⁸ EPO Guidelines 2025, Part G-II, 3.3 and 3.3.1.

⁶³⁹ In this direction see: Christian Heinze and Andreas Engel, 'KI und Patentrecht' in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 83; Eva Stanková, 'Human Inventorship in European Patent Law' (2021) 80 *The Cambridge Law Journal* 14; Bernhard Volmer, 'Die Computererfindung: Unter besonderer Berücksichtigung des Arbeitnehmererfinderrechts' (1971) *Mitteilungen der deutschen Patentanwälte* 258 et seq.; opposed to: EPO, J 8/20, 21 December 2021 (*Designation of inventor/DABUS*); Roman

Such a requirement could be present in Category IV inventions but would be lacking in Category V inventions. Therefore, *Stanková* suggests that an invention shall be understood as “something owing its existence to a certain kind of human activity or intervention”.⁶⁴⁰ According to this line of thoughts, a product that would otherwise meet the requirements for patentability would lack protectability solely due to the absence of human intellectual input.⁶⁴¹

The question of whether a human inventive act is a necessary condition for the existence of an invention is often answered affirmatively with reference to the inventor principle, according to which no invention is conceivable without an inventor.⁶⁴² This ties the concept of invention to the notion of the inventor, who, under current law, must be a natural person. However, this interpretation is challenged when considering the purpose of the inventor principle, which is to legally attribute the invention to a person,⁶⁴³ rather than to determine the meaning of “invention” itself.⁶⁴⁴ Still, to clarify the matter, a *de lege ferenda* perspective, considering what the law ought to be, amending Article 52 EPC could enhance the patentability of AI-related innovations while preserving the core principles of the Article. As for Category IV-V inventions, Article 52 EPC does not explicitly address AI-generated outputs, creating potentially legal uncertainty regarding their patent eligibility. Established case law, such as decisions T 1173/97 and G 3/08, confirms that software-based inventions may be patentable if they produce a “further technical effect”, but this jurisprudence does not directly address the distinct challenges posed by autonomous AI systems or inventions generated with minimal human intervention.⁶⁴⁵ To remedy this, it could be useful to introduce a clarifying provision, such as a new Article 52(3a) EPC, stating that (a) inventions are not excluded from patentability solely because their creation process involves AI, provided the output solves a technical problem or produce a technical effect.⁶⁴⁶ Although this update does not seem necessary at the current state of technology, it could be useful as a clarification.

Moreover, a rethinking appears necessary regarding the traditional notion of invention as being embedded within specific solutions. Increasingly, it seems that the inventive aspect may lie in posing a specific technical problem, with solutions often generated by widely used AI systems. However, it is important to note that the concept of “problem inventions”, which suggests that identifying an unrecognized problem can lead to patentable subject matter, is rarely utilized

Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für geistiges Eigentum* 388 et seq.

⁶⁴⁰ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 15 *The Cambridge Law Journal* 11 et seq.

⁶⁴¹ Christian Heinze and Andreas Engel, ‘KI und Patentrecht’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 83.

⁶⁴² BGH, Judgment of 5 May 1966, Ia ZR 110/64 *Spanplatten* [1966] GRUR 558, 560; see also: Christian Heinze and Andreas Engel, ‘KI und Patentrecht’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 83; for a deeper analysis the implications of authorless works see: Tim W Dornis, ‘Of “Authorless Works” and “Inventions without Inventor”-The Muddy Waters of “AI Autonomy”’ (2021) 43(9) *European Intellectual Property Review* 570 et seq.

⁶⁴³ Compare Article 60(1) sentence 1 EPC.

⁶⁴⁴ Christoph Ann, *Patentrecht* (Munich 2022) § 17 para 13.

⁶⁴⁵ EPO, T 1173/97, July 1998 (*Computer program product/IBM*), § 6; EPO, G 3/08, 12 May 2010 (*Programs for computers*).

⁶⁴⁶ EPO Guidelines 2025, Part G-II, 3.3.1; Eva Schulte, ‘Patentability of AI-Generated Inventions: Legal Challenges and Reform Proposals’ (2023) *IIC* 521.

under the EPO's problem-solution approach.⁶⁴⁷ This approach emphasizes the formulation of an objective technical problem based on prior art and distinguishing features of the claimed invention, rather than relying on the identification of a subjective problem as a basis for inventive step. While discovering an unrecognized problem can sometimes result in a patentable invention, even if the solution appears obvious or trivial when viewed in hindsight, this raises questions about how AI-related inventions fit into the framework.⁶⁴⁸ In cases where human involvement is limited to defining a problem for an AI to solve, classifying these scenarios as "problem inventions" becomes complex.⁶⁴⁹ For AI tools, "posing a problem" often means formulating it as a mathematical function that the AI can process to achieve a desired result.⁶⁵⁰ While the problem itself might seem conceptually obvious, translating it into mathematical terms can require significant skill. For instance, if an AI tool is instructed to create a new manufacturing process for a known issue, while the problem may be evident to the AI, the solution it generates could still be innovative. The complexity involved in framing problems mathematically does not necessarily diminish their obviousness. Therefore, in such cases, the approach of "problem inventions" may not apply because any inventive contribution lies more with the AI-generated solution rather than with defining the problem itself.⁶⁵¹ Nevertheless, there may be instances where an inventor identifies a previously unnoticed problem and utilizes an AI tool to solve it; this could be considered a "problem invention", though this situation is not inherently specific to AI.⁶⁵²

Still, since patent law does not consider the process by which an invention came into being (accidental inventions are also patentable), it should also not distinguish whether an invention was developed with or without the involvement of AI and therefore focus on the objective criteria of novelty, industrial applicability and inventive step.⁶⁵³ Therefore, the use of AI should not preclude the existence of an invention under Article 52 EPC.⁶⁵⁴ The invention itself would exist, regardless of if the patentability requirements are being fulfilled, since Article 53 EPC, does not deny the existence of an invention, but only exclude its protection at a subsequent stage.⁶⁵⁵

⁶⁴⁷ Phillip Johnson, 'Article 56 EPC', in R Hacon and J Pagenberg (eds.), *Concise European Patent Law* (2nd ed., Wolters Kluwer, 2008) 57.

⁶⁴⁸ In case law see: EPO, T 2/83, 15 March 1984 (*Simethicone Tablet / Rider*); EPO, T 764/12, 18 February 2014 (*Gumlink*); EPO, T 109/82, 15 May 1984 (*Hearing aid/Bosch*).

⁶⁴⁹ Daria Kim et al., 'Clarifying Assumptions About Artificial Intelligence Before Revolutionising Patent Law' (2022) *GRUR International* 298.

⁶⁵⁰ Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 250-251.

⁶⁵¹ Phillip Johnson, 'Article 56 EPC', in R Hacon and J Pagenberg (eds.), *Concise European Patent Law* (2nd ed., Wolters Kluwer, 2008) 57.

⁶⁵² Daria Kim et al., 'Clarifying Assumptions About Artificial Intelligence Before Revolutionising Patent Law' (2022) *GRUR International* 300.

⁶⁵³ Christian Heinze and Andreas Engel, 'KI und Patentrecht' in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 83; Martin Stierle, 'A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System' (2021) *GRUR International* 121.

⁶⁵⁴ Sven Hetmank and Anne Lauber-Rönsberg, 'Künstliche Intelligenz – Herausforderungen für das Immaterialgüterrecht' (2018) *GRUR* 576; Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für geistiges Eigentum* 389 et seq.

⁶⁵⁵ Viktoria Schrön, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Baden-Baden 2023) 134-135.

While these considerations are doctrinally important, they do not represent the central legal challenge in the context of AI-related inventions in Categories IV-V. In such cases, AI systems often produce tangible technical outputs, a novel compound or a structural design, such as *Thaler's* inventions, that readily meet the threshold of technical character. The fact that an invention exists, in the sense of a technical solution to a technical problem, is therefore mostly not the main problematic issue in these categories. Thus, the issue of subject-matter eligibility is not fundamental as the core challenges lie elsewhere, particularly in the application of inventive step.

2. Novelty, Inventive Step and Industrial Application

Apart from the patentable subject matter, according to Article 52 EPC an invention must fulfil the substantive patentability requirements of being novel, involve an inventive step, and be capable of industrial application.

The requirement of novelty asserts that any subject matter already within the public domain, known as the “state of the art”, at the time of application filing, cannot be patented.⁶⁵⁶ When evaluating an invention’s novelty, meaning it was “not part of the existing state of the art, the prior art document must be considered as it was at the time of its publication” (see Part E).⁶⁵⁷ Article 54(2) EPC states not only that an invention shall be considered new if it does not form part of the state of the art, but it also defines the state of the art as “to comprise everything made available to the public by means of a written or oral description, by use, or in any other way, before the date of filing of the European patent application”.⁶⁵⁸ A lack of novelty is significant for an invention for two main reasons. First of all, it is unlikely that patent rights can be secured for a non-new idea. In most cases, this means that the idea has little or no commercial value. Secondly, an idea that is not new cannot legally belong to the one that claims it. If someone else owns the rights, the second “inventor” risks being prosecuted if he tries to use the idea without the permission of the patent holder.

The novelty of inventions created by an AI will strongly vary according to the inventive process being used. The novelty can be missing if the algorithm being used lacks variability in its outputs, as well as if it is based on similar datasets. If an algorithm embodies randomness or other variability, it can be expected that it will generate novel inventions.⁶⁵⁹ AI even has the capability to rapidly and carefully re-examine more prior art than it would be feasible for a human inventor, features that can be embedded in invention-generation technologies to secure additional novelty. AI will create a new paradigm of novelty, given that computers are constantly generating new results. Still, by not using AI in the prior art search, only what is available to a person would be considered, whilst what is available to a computer would not be treated as prior art. Consequently, computers could access and use inventions available to other

⁶⁵⁶ Article 54 EPC.

⁶⁵⁷ EPO Guidelines 2025, Part G-VI, 3.

⁶⁵⁸ Article 54(2) EPC.

⁶⁵⁹ Liza Vertinsky and Todd M Rice, ‘Thinking about thinking machines: Implications of Machine Inventors for Patent Law’ (2002) 8(2) *Boston University Journal of Science and Technology Law* 576; Ross D King et al., ‘The Robot Scientist Adam’ (2009) 42(7) *Computer* 46 et seq.

computers but not to humans, often because not understandable, and therefore not considered prior art. On the contrary, if AI expands what is understandable by humans, it would be harder to establish novelty and thus patentability.⁶⁶⁰ This reasoning can also be applied to the inventive step and will be further examined in Section D.IV).

Even if an idea is new, novelty alone cannot be enough. In order for an invention to have a good economic potential, it must represent a significant improvement of the state of the art. This depends on many factors and improvements that may be small, can have a high commercial value.⁶⁶¹ Even so, it is possible that an idea of economic success is new, but not inventive.⁶⁶² The condition of the inventive step expands upon novelty by disallowing patents for subject matter that, although not publicly disclosed, would have been reasonably attainable or foreseeable by someone skilled in the relevant field. While the inventiveness requirement aims to prevent exclusivity from being granted to any idea for solving a technical problem simply because it was not already included in the state of the art, the novelty requirement pursues the goal of not granting it to an invention already made by others or in the public domain.⁶⁶³

The assessment of the presence of an inventive step under Article 56 EPC is based on three essential elements:

- (a) the identification of the technical field in which the invention operates;
- (b) the definition of the person skilled in the art; and
- (c) the evaluation of whether the invention would have been obvious to such a person.

The “qualified quantum” of innovation that enables the invention to be sufficiently different from the state of the art might be connected to inventive activity in this manner.⁶⁶⁴ Due to the fact that if an invention is foreseen in the state of the art, any possibility of an inventive step in respect to the same state of the art is eliminated, it may be claimed that the novelty requirement comes before the inventive activity requirement, both legally and rationally.⁶⁶⁵ The question of the inventive step therefore only arises if there is novelty.⁶⁶⁶ Still, the significance of the inventive step lies in the fact that it serves as a critical threshold for distinguishing mere novelty from true innovation. Given the crucial role that the inventive step plays in assessing the

⁶⁶⁰ Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 489; for a general discussion see: William Samore, ‘Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?’ in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018).

⁶⁶¹ Ibid, stating that for example, the drinks can ring-pull is simple technology, but its advantages - (a) it is secured by a rivet that does not penetrate the can, and (b) the underside of the ring is shaped to give mechanical advantage - made it a significant invention with huge commercial value.

⁶⁶² Ibid.

⁶⁶³ Giorgio Floridia, ‘I requisiti di proteggibilità’ in P Auteri et al. (eds), *Diritto industriale: proprietà intellettuale e concorrenza* (Giappelli 2020) 273; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.; Giuseppe Sanseverino, ‘The Ability to Chase Down Our Dreams. Inventive Step and Artificial Intelligence’ (2018) *I Battelli del Reno* 11.

⁶⁶⁴ Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 107 et seq.; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁶⁶⁵ Alberto Musso ‘Ditta e insegna, marchio, brevetti, disegni e modelli, concorrenza’ in G De Nova (ed), *Commentario del codice civile e codici collegati Scialoja-Branca-Galgano* (Bologna 2012) 668; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁶⁶⁶ EPO Guidelines 2025, Part G-VII, 1.

patentability of an invention, this concept forms the core of this thesis and will be examined in depth examined starting from Section D.IV).

Lastly, an invention is considered to possess industrial applicability when it can be made or used within any kind of industry.⁶⁶⁷ Therefore, knowledge that cannot be exploited industrially and cannot be used in at least one kind of industry remains unpatentable as inventions.⁶⁶⁸ Even though there are exceptions,⁶⁶⁹ the ratio behind the law is to avoid inventions that lack practical importance and usage. The industrial nature of an invention, therefore, necessitates that the means employed to realize it should predominantly be of an industrial character, and the outcome itself must also exhibit industrial qualities, rather than emerging from purely intellectual activities. With the increasing prevalence of AI-related inventions, meeting this requirement has become more complex. To prevent unjustified monopolization and ensure AI-related inventions are not dismissed as mere abstract ideas, it may be sufficient, for instance, if the invention's result contributes to the transformation of a tangible object or is closely tied to a physical entity. Consequently, it is advisable to include as many structural features as possible in a patent application to provide sufficient opportunities to link an algorithm to a specific object. The EPC's requirement for inventions to be suitable for industrial application is closely aligned with the necessity for the invention to make a technical contribution.⁶⁷⁰

3. Preliminary Results

The criteria for patentability under the EPC, subject matter eligibility, novelty, inventive step, and industrial applicability, apply to all inventions, including those related to AI. However, these requirements become, at least partially complex when applied to AI inventions, especially given the opaque nature of AI systems and their often unpredictable processes.

The notion of “invention” under the EPC lacks a precise definition, leading to interpretive flexibility. Patent law differentiates between discoveries and inventions, with inventions requiring human ingenuity. The EPO's approach requires demonstrating a “technical

⁶⁶⁷ Article 57 EPC.

⁶⁶⁸ In most cases, there is typically no need for explicit elaboration on how inventions can be utilized in industry. This notion is reflected in the EPO Guidelines, which state that the self-evident nature of an invention's industrial applicability often renders further explicit description unnecessary. Similarly, under US patent law, a requirement for patentability is that an invention must possess “utility”, implying practical usefulness or functionality (See: Kilburn & Strode, ‘Industrial Applicability and Why It Matters’ (Kilburn & Strode, 2023) <https://www.kilburnstrode.com/knowledge/european-ip/industrial-applicability-and-why-it-matters>; EPO Guidelines 2025, Part F-II, 4.9; USPTO, ‘MPEP Section 2104 - Requirement of Utility’ (USPTO) <https://www.uspto.gov/web/offices/pac/mpep/s2104.html>).

⁶⁶⁹ EPO, T 541/96, 7 March 2001 (*Element and energy production device*) (the BoA has decided that one exception is when the invention is ‘contrary the law of physics’).

⁶⁷⁰ Stefan Wagner, ‘Business Method Patents in Europe and Their Strategic Use - Evidence From Franking Device Manufacturers’ (2008) 17 *Economics of Innovation and New Technology* 173-194; John R Allison and Emerson H Tiller, ‘The Business Method Patent Myth’ (2003) 18 *Berkeley Technology Law Journal* 987-1084, Charlotte Beale, ‘Fourth Industrial Revolution Technology Patents are Flourishing’ (World Economic Forum, 11 December 2017) <https://www.weforum.org/agenda/2017/12/fourth-industrial-revolution-technology-patents-internet-things-smart-object> (discussing on noting a significant increase in the volume of patent applications submitted in Europe related to technologies like AI and smart objects).

character”, which ensures that the invention solves a technical problem through technical means.

Although the EPC does not explicitly address AI-related inventions, such inventions are to be assessed under existing patentability criteria, requiring a technical character and contribution to a technical problem. Advanced AI systems (Categories IV-V) can autonomously generate inventive outputs, yet the lack of human involvement does not inherently preclude patent protection. While AI-related inventions must be described with sufficient technical specificity, a key challenge lies in identifying the technical features relevant to inventive step. The necessity of a human inventive act remains debated, though current law ties inventorship to natural persons. A suggestion could be to amend Article 52 EPC to clarify that AI-related inventions are not excluded if they produce a technical effect. Overall, the core legal issue does not seem to be subject-matter eligibility.

Within this framework, novelty and inventive step remain central to assessing the patentability of AI-related inventions. Novelty requires that the invention is not part of the prior art, while the inventive step must not be obvious to a skilled person. AI’s capacity to generate novel solutions autonomously can complicate these assessments, especially when AI systems produce results beyond human understanding. The inventive step must demonstrate that the AI-related solution is non-obvious and presents a significant advancement over the state of the art.

Finally, the last patentability requirement of industrial applicability requires that the invention can be made or used in any industry. In AI-related inventions, the challenge lies in ensuring that the invention contributes to a physical or industrial outcome, preventing abstract ideas from being patented. This requirement is closely tied to the technical character criterion, emphasizing that AI inventions must produce tangible, industrially applicable results to qualify for patent protection.

In conclusion, AI-related inventions must navigate the established patentability framework under the EPC, with a focus on demonstrating technical character, novelty, inventive step, and industrial applicability. The unique nature of AI inventions, particularly their reliance on abstract algorithms and autonomous processes, requires careful consideration to meet these criteria.

IV. Assessment of Inventive Step and AI Challenges

1. Background and Evolution of the Concept of Inventive Step

The inventive step requirement is often defined at the same time as the most important, most problematic, and the most litigated requirement for patentability.⁶⁷¹ It is particularly important,

⁶⁷¹ Friedrich K Beier, ‘The inventive step in its historical development’ (1986) *IIC* 301-303; John F Witherspoon, *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs, Washington 1979); Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 688; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 194; Stefan Luginbühl, ‘Patent

because it serves as the principal threshold for patentability, ensuring that the invention represents a non-obvious technical advancement rather than a routine or abstract output.

The requirement reflects the intellectual activity involved in solving a technical problem. It is nowadays, in its different forms and wordings, a prerequisite for the patentability of an invention in most patent systems. It determines whether an invention is sufficiently inventive to be eligible for patent protection and it mandates that the invention must not only be new but also involve a certain level of “progress” from the prior art.⁶⁷² The aim is to ensure that patents are granted solely for inventions that demonstrate genuine innovation.

The requirement of an inventive step mandates that the invention must not be “obvious” to a person skilled in the relevant field. The word “obvious” traces back to the Latin word “*obvius*”, which means “in the way” or “in the presence of”, and in the field of innovations it implies something that would be the following legitimate advance along the way.⁶⁷³ The EPO Guidelines generally define the term “obvious” as something that “does not go beyond the *normal progress* of technology”, following logically from the prior art, and does not imply the exercise of any “ability beyond that to be expected of the person skilled in the art”.⁶⁷⁴

Deciding what may involve an inventive leap or level of inventiveness can be challenging. Numerous developments include combinations of known elements, and the effects of such mixes may result in another item, yet its properties or functionality may be completely unsurprising, resulting in an invention that does not contribute significantly to technological progress since it is entirely predictable or expected based on the known elements and therefore likely be considered obvious.⁶⁷⁵ The combination of known items or methods may yield results that surpass the sum of their individual parts, producing unexpected or enhanced outcomes, which can be regarded as a non-obvious invention. Then again, an invention could emerge from selecting the best solution out of multiple solutions, where the inventiveness lies in the identifying and selection process.⁶⁷⁶

Protection of Inventions Involving Artificial Intelligence’ in *Transition and Coherence in Intellectual Property Law: Essays in Honour of Annette Kur* (Cambridge University Press, Cambridge 2021) 194; Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 119; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁶⁷² Agreement on Trade-Related Aspects of Intellectual Property Rights (adopted 15 April 1994, entered into force 1 January 1995) 1869 UNTS 299, article 27. See also: Hanns Ullrich, ‘TRIPS: Adequate Protection, Inadequate Trade, Adequate Competition Policy’ in Friedl Weiss and Silke Steiner (eds), *WTO and Global Governance: Future Directions* (Routledge 2012) 120, noting that TRIPS sets minimum standards, including the requirement of inventive step, without harmonising the methodology of assessment.

⁶⁷³ Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁶⁷⁴ EPO Guidelines 2025, Part G-VII, 4.

⁶⁷⁵ EPO, ‘Inventors Handbook: Is the idea “obvious”?’ <https://www.epo.org/learning-events/materials/inventors-handbook/novelty/obvious.html>.

⁶⁷⁶ Copyright protects the specific, individual expression of a work, such as a tangible computer program, but does not extend to automatically generated programs or the underlying ideas and principles. Even simple programs are covered by copyright, and if a third party creates a new program based on an idea from another program, a new copyright is established for the third party’s work. In contrast, patent law assesses the inventive step of an invention objectively, without considering how it was developed. This means a computer-generated invention can be patentable, even if the human contribution was minimal. Unlike copyright, patent law is designed as a registered right, allowing the applicant to claim protection through the formal registration process. The criticism voiced by Kummer against the doctrine of presentation that intellectual property protection is put at the disposal of the potential right holder does not apply here. On the contrary, the legislator has already actually put the creation of

Through history, the assessment of inventions worthy of patent protection has been conducted in different ways and with different thresholds in mind in different jurisdictions.⁶⁷⁷ Historically, the Venetian Inventor's Statute of 1474, is one of the earliest examples of patent legislation. This statute protected "new and ingenious devices" from imitation, implicitly requiring some degree of originality and creativity, although it did not explicitly define the concept of an inventive step.⁶⁷⁸

The concept was more formally recognized in the mid-19th century with the United States Supreme Court case *Hotchkiss v Greenwood* (1850), which suggested that an invention must require more ingenuity than that possessed by an ordinary mechanic in the field.⁶⁷⁹ This case set a precedent, at least in the United States, for considering the inventive step as essential for patentability. In the United States, since the 1850s, the requirement for patentability is based on the concept of "non-obviousness" instead of the inventive step. Even though the concept behind the two requirements is similar, mainly requiring that an invention must be sufficiently inventive, thus it must not be obvious to be patented, there are differences in the assessment.⁶⁸⁰ The fundamental concept that an invention must possess a sufficient degree of inventiveness or non-obviousness to qualify for patent protection remains the same.⁶⁸¹ The inventive step should be defined purely objectively and not based on the creation process of the invention.⁶⁸² The law declares the manner of the invention's creation as irrelevant, meaning that no special requirements are imposed in this regard.⁶⁸³ 35 USC § 103, which corresponds to Article 56 EPC, explicitly states that "patentability shall not be negated by the manner in which the invention was made".⁶⁸⁴ Consequently, it is "immaterial whether it [the invention] resulted from long toil and experimentation or from a flash of genius".⁶⁸⁵

In Germany, whilst the 1877 Imperial Patent Act required novelty and industrial applicability, the inventive step (first *Erfindungshöhe*, namely "inventive height", and later *erfinderische Tätigkeit* to harmonize German patent law with international standards, particularly considering the EPC) was codified in the 1978 Patent Act.⁶⁸⁶ According to Section 1 of the German Patent

patent law at the applicant's disposal by designing it as a register right (Max Kummer, *Das urheberrechtlich schützbares Werk* (Stämpfli, Bern 1968) 106 et seq.).

⁶⁷⁷ For a detailed illustration of the history of the inventiveness requirement see: Lodewijk Pessers, *The Inventiveness Requirement in Patent Law: An Exploration of Its Foundations and Functioning* (1st edn, Kluwer Law International 2016) chapter 2, § 2.1.

⁶⁷⁸ The Venetian Inventor's Statute is presumably the oldest patent legislation in the world and it was strikingly discovered only in the mid-twentieth century by the Italian researcher Giulio Mandich (Giulio Mandich, 'Le privative industriali veneziane' (1936) *Rivista del diritto commerciale* 511; see also: Helmut Schippel, *La storia delle privative industriali nella Venezia del '400* (Centro tedesco di studi veneziani, Venezia 1989) 38.

⁶⁷⁹ *Hotchkiss v Greenwood* 52 US 248 (1850).

⁶⁸⁰ Different patent offices use various methods to evaluate the inventive step: The EPO uses the "problem-and-solution approach" whereas the USPTO applies the "Graham factors".

⁶⁸¹ For a general discussion see: John H Barton, 'Non-obviousness' (2003) 43(3) *Idea (Concord, NH)*, 475-508 passim.

⁶⁸² Oskar Paulini, 'Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz' 23 (PhD thesis, LMU Munich 2023) 62.

⁶⁸³ *Ibid.*

⁶⁸⁴ 35 USC § 103 (1952).

⁶⁸⁵ 35 USCA § 103 (1954), Historical & Revision Notes thereto.

⁶⁸⁶ Friedrich K Beier, 'Zur historischen Entwicklung des Erfordernisses der Erfindungshöhe' (1985) *GRUR Inland* 606 et seq.; Alfred W Kumm, 'Die Bewertung der erfinderischen Tätigkeit – ein rational unlösbares Jahrhundert-Problem' (1998) *epi (European Patent Institute) Information* 23–26.

Act, for example, the existence of an inventive step is required for the grant of a patent on an invention. Section 4 then defines in more detail that “an invention shall be deemed to involve an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art”. Articles 52⁶⁸⁷ and 56 EPC follow the same legislative system as Sections 1 and 4 of the German Patent Act and Articles 6 and 10 of the French Patent Act.⁶⁸⁸ Both German and French patent application practices have identified various types of inventive activities that may meet the necessary intellectual activity standard, such as overcoming technical obstacles, formulating a new technical problem, answering difficult questions, challenging biases or stereotypes, surprising a person skilled in the art, making a selection from numerous possible solutions, or combining at least three prior art documents.⁶⁸⁹ As such, jurisprudence provides guidance on the types of activities that may meet the standard for devising an invention.⁶⁹⁰

In drafting the EPC, the parties intentionally chose not to include the German concept of “inventive height” (*Erfindungshöhe*) for two main reasons.⁶⁹¹ First, they aimed to create a text that was independent of national legal traditions, which would allow for the future evolution of European patent law. Incorporating a term that lacked equivalent translations in other languages would have undermined this objective. Second, there was concern among the other countries that a direct translation of “inventive height” could lead to an unjustified increase in the standards required for a patentable invention.⁶⁹² Despite these considerations, the majority of the represented countries did not wish to exclude the possibility of adding a third criterion for patentability, alongside novelty and industrial applicability. This additional criterion would entail a requirement for a certain level of inventive quality without explicitly using the German term “inventive height”.⁶⁹³

In the United Kingdom, according to the Patent Act of 1932, to be patentable an invention must be a new principle created with diligence and ingenuity based on an inventive step. Although the inventor’s personal assessment of its efforts and the way in which they made their invention are supposedly disregarded, the United Kingdom courts do consider “secondary evidence” such as contemporaneous events, reactions to the invention, and the practical realities of making the invention, in addition to the actual methods used to approach the objective technical problem

⁶⁸⁷ Article 52 EPC.

⁶⁸⁸ ‘Code de la Propriété Intellectuelle’ (Legifrance, 29 December 1992) <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000317285/#LEGIARTI000006281059>.

⁶⁸⁹ To determine whether an invention is obvious or not, the judge or patent office usually assesses whether an average technician, at the time the patent application was filed, would have found the invention obvious based on the existing prior art. This involves comparing the state of the art with the essence of the invention and accurately identifying any new technical problems or solutions. The assessment may involve not just solving a known technical problem but also formulating a new problem or identifying the underlying process of a phenomenon, the application of which in industry becomes obvious. (Rudolf Busse et al., *Patentgesetz* (8th ed. Munich, 2016) §4 [116]; Vincenzo Di Cataldo, *L’originalità dell’invenzione* (Giuffrè 1983) 78).

⁶⁹⁰ Such general alternatives are often closely tied to the specific sector originally considered by patenting practices, such as mechanics, and may not be suitable for other fields. In the chemical sector, for instance, the focus is less on the structure or method of creating the product and more on predicting its properties. As a result, identifying the objective technical problem to assess the presence of an inventive step may require different analytical approaches (Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 103).

⁶⁹¹ Jochen Pagenberg, ‘The Concept of the “Inventive Step” in the European Patent Convention’ (1974) *IIC* 157.

⁶⁹² *Ibid.*, 158.

⁶⁹³ *Ibid.*

at hand.⁶⁹⁴ Telling the story of how an inventor came up with their invention can be considered and work in favour of the patent holder.⁶⁹⁵

The Patent Cooperation Treaty of 1970 requires at its Article 33 the existence of an inventive step and affirms that “a claimed invention shall be considered to involve an inventive step if, having regard to the prior art as defined in the Regulations, it is not, at the prescribed relevant date, obvious to a person skilled in the art”.⁶⁹⁶

Nowadays, across jurisdictions, the assessment of inventive step generally centres on whether the invention would have been obvious to a person skilled in the art in view of the relevant prior art. In most legal systems, it is required that such a person could not have readily derived the invention from existing knowledge, as reflected for example in the approaches of Japan and the Republic of Korea.⁶⁹⁷ Some jurisdictions emphasise that the invention must exhibit significant substantive features or represent notable technical or economic advancement in comparison to prior art, as in the case of China and India. Other jurisdictions, such as the Nordic countries, focus on whether the invention differs essentially from the state of the art.⁶⁹⁸

2. The Notion of Inventive Step as Regulated by the EPC

The notion of inventive step is grounded in Article 52(1) EPC, which deems inventions patentable if they, amongst other requirements, involve an inventive step. Article 56 EPC specifically defines the inventive step requirement.⁶⁹⁹ According to Article 56 EPC, “an invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art”.⁷⁰⁰ To measure inventiveness, Article 56 EPC provides a legal presumption of inventive activity by defining an invention as involving an inventive step if it is not obvious to a person skilled in the art, based on the state of the art. To

⁶⁹⁴ A list of secondary factors was provided by Justice Laddie in *Haberman v Jackel International Ltd* [1999] FSR 683, 699-701.

⁶⁹⁵ *Actavis Group PTC Ehf and others v ICOS Corporation and another* [2019] UKSC 15 [71]; *Positec Power Tools (Europe) Ltd v Husqvarna AB* [2016] EWHC 1061 (Pat) [8].

⁶⁹⁶ WIPO, ‘Patent Cooperation Treaty (PCT), Article 33’ <https://www.wipo.int/pct/de/texts/articles/a33.html>.

⁶⁹⁷ WIPO, ‘Study on Inventive Step’ (Standing Committee on the Law of Patents (SCP), 22nd Session, July 27 to 31, 2015) Presentation by the Secretariat https://www.wipo.int/edocs/mdocs/scp/en/scp_22/scp_22_presentation_inventive_step.pdf, 7.

⁶⁹⁸ Ibid.

⁶⁹⁹ Human creativity is not a fundamental requirement for patentability, and a human mental act is not necessary under Article 52 et seq. of the EPC. The titles of Article 56 EPC in the French and German versions are somewhat misleading, as they suggest some form of activity is involved. However, the actual provision simply compares the claimed invention to solutions that would be obvious to a hypothetical person skilled in the art. The identity of the actual inventor, whether human or artificial, is not examined by the EPO or national courts under Article 56 EPC, nor is there any obligation to explain how the invention was developed or conceptualized (Ben Hattenbach and Joshua Glucoft, ‘Patents in the Era of Infinite Monkeys and Artificial Intelligence’ (2015) 19 *Stanford Technology Law Review* 44); Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für geistiges Eigentum* 389 et seq.; Nick Li and Tzeyi Koay, ‘Artificial Intelligence and Inventorship: An Australian Perspective’ (2020) 15(5) *JIPLP* 400; EPO, ‘Comments by the European Patent Office, WIPO Conversation on Intellectual Property (IP) Artificial Intelligence (AI), Second Session July 7 to 9, 2020, Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence’ (WIPO/IP/AI/2/GE/20/1 REV) 2 et seq. https://www.wipo.int/meetings/en/details.jsp?meeting_id=55564).

⁷⁰⁰ Article 56 EPC; decisions/opinions of the Enlarged Board of Appeal G 2/98, G 3/98, G 2/99, G 1/03, G 2/03.

be granted a patent under the EPC, an invention must therefore represent (amongst others) progress or advancement in the state of the art.⁷⁰¹ The criterion of the inventive step is purely objective, which means that the personal assessment or subjective achievements of the inventor are typically disregarded in the assessment of inventiveness.

The inventive step requirement selects from among all that is new, what is different from the state of the art, and is therefore not a normal development of a specific sector, but an invention worthy of patent protection.⁷⁰² To do so a comparison between the prior art and the invention needs to be made from the standpoint of a “person skilled in the art” and in order to be patentable there needs to be an inventive step compared to the prior art available. Inventiveness is therefore measured objectively against an average expert’s hypothetical capability, and an inventor must do what an average expert would not have done to create an inventive invention.⁷⁰³ The responsibility of determining these concepts falls upon the practices of the EPO and the decisions made by the BoA.⁷⁰⁴ The EPO provides guidance on how to assess the inventive step, including the use of the “problem-and-solution approach”, which involves identifying the closest prior art, determining the technical differences between the invention and the closest prior art, and assessing whether those differences would have been obvious to a person skilled in the art. If there are doubts about the existence or the lack of an inventive step, objections are raised in the examination procedure and, if they cannot be dismissed, for example by formulating more specific patent claims, the patent application is rejected.

The EPO does not examine whether an intellectual activity was involved in solving the underlying problem, but instead focuses on the inventiveness standard as judged by a person skilled in the relevant technical field.⁷⁰⁵ Under the problem-solution approach, this fictional skilled person is presumed to have ordinary knowledge and capabilities but lacks inventive insight. The current application of the inventive step requirement often reduces to a structured comparison between the claimed invention and the closest prior art, identifying distinguishing features and assessing whether these would have been obvious to the skilled person. As a result, the assessment can become a mechanistic exercise focused more on technical plausibility than on the actual presence of creative or intellectual contribution. This may lead patent authorities to overlook the normative purpose of the inventive step requirement, namely, to reward non-obvious intellectual achievements that genuinely advance the state of the art, since the focus is

⁷⁰¹ A mere disadvantageous modification of the closest prior art does not constitute an inventive step (*T 2197/09* (20 November 2014) EP:BA:2014.20141120, [5.4]).

⁷⁰² Vincenzo Di Cataldo, *Le invenzioni. I modelli* (2 edn, Giuffrè 1993) 45, stating that the inventive step delineates the threshold between what falls within the routine progression of a particular field - achievable by any practitioner within that domain, and thus unworthy of patent protection - and what results from an idea that surpasses the standard expectations of the sector’s development, which is not readily attainable by the majority of its operators, and therefore justifies the grant of exclusive rights; on the matter see also: Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁷⁰³ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 17.

⁷⁰⁴ Comparing various jurisdictions, Article 56 EPC, is similar to Article 47 of the Italian Intellectual Property Code, Section 3 of the United Kingdom Patent Act, and Section 4 of the German Patent Act (Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 12; see also: Bardehle Pagenberg, ‘Assessment of Inventive Step under the EPC’ (2021) https://media.bardehle.com/contentdocuments/broschures/Assessment_of_Inventive_Step_under_the_EPC.pdf.

⁷⁰⁵ Phillip Johnson, ‘Article 56 EPC’, in R Hacon and J Pagenberg (eds.), *Concise European Patent Law* (2nd ed., Wolters Kluwer, 2008) 52.

not on whether a human inventor exercised creativity, but rather on what the notional skilled person would have done based on existing knowledge.⁷⁰⁶

However, the EPC does not clearly define the terms “obvious” and “person skilled in the art” and does not outline any methods for evaluating obviousness. Also, the *quantum* of inventiveness required for an invention to be considered inventive is a result of an interpretative activity carried out on a case-by-case basis by the patent office and must be in line with the function of the system considered as a whole.⁷⁰⁷ There is tension in various accounts regarding how to define the inventive activity under the EPC. Some require that the invention represents a manifestation of intelligence that exceeds the normal train of thought of any specialist in the relevant field, while others state that breaking new ground and applying some intellectual activity is enough.⁷⁰⁸ As an international public law treaty, the EPC must be interpreted in good faith according to its ordinary meaning, context, and purpose.⁷⁰⁹ Therefore, despite the differences, there is a consensus that genuine intellectual activity is required in the process of inventing.

3. The Problem-and-Solution Approach at the EPO

The specific tests and factors used to assess the inventive step differ amongst patent systems somewhat, reflecting differences in legal and cultural traditions.⁷¹⁰ For the assessment of the inventive step, the so-called “problem-and-solution approach” has been developed by the BoA and finds support *inter alia* in Rule 42(1)(c) Implementing Regulations of the EPC.⁷¹¹ It enables, although not mandatory,⁷¹² a structured, objective, transparent and comprehensible assessment by the EPO during an examination of a patent claim.⁷¹³ Fundamentally, this method

⁷⁰⁶ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 19.

⁷⁰⁷ Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 119; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁷⁰⁸ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 17.

⁷⁰⁹ *Vienna Convention on the Law of Treaties* (1969) art 31 (opened for signature 23 May 1969, entered into force 27 January 1980) 1155 UNTS 331.

⁷¹⁰ The United Kingdom courts use a four-parts test: (i) identifying the inventive concept underlying the patent; (ii) identifying the relevant common general knowledge; (iii) identifying the differences between the invention and the prior art; and (iv) determining whether those differences would have been obvious to a person skilled in the art. Under United States patent law, it is required that an invention is non-obvious to a person having ordinary skill in the art. The invention must therefore not be an obvious extension or variation of existing technology. United States courts use the so-called Graham test to assess non-obviousness, which involves analysing four factors: (i) the scope and content of the prior art; (ii) the differences between the prior art and the claimed invention; (iii) the level of ordinary skill in the relevant art; and (iv) any secondary considerations, such as commercial success or long-felt but unresolved needs.

⁷¹¹ The description must “disclose the invention, as claimed, in such terms that the technical problem, even if not expressly stated as such, and its solution can be understood, and state any advantageous effects of the invention with reference to the background art”.

⁷¹² Kaisa Suominen et al., *Visser’s Annotated European Patent Convention* (Wolters Kluwer, Alphen aan den Rijn 2022) 197, stating that although the analysing of the inventive step through the problem-and-solution approach is not mandatory, it is very unusual for the EPO to take any other approach.

⁷¹³ Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 689.

aims to ensure an objective assessment of inventive step and to prevent retrospective reasoning based on prior art, commonly referred to as “hindsight”.⁷¹⁴

Although the EPC does not explicitly mention the problem-and-solution approach in any of its articles, the EPO Guidelines instruct examiners to generally apply this method. This is illustrated in T 1/80, where the headnotes officially indicate that determining the objective technical problem based on objective criteria must precede the assessment of inventiveness.⁷¹⁵ However, the broad application of the problem-and-solution approach was challenged in subsequent cases (T 465/92⁷¹⁶ and T 939/92⁷¹⁷). Nonetheless, the EPO consistently addresses the issue of obviousness by objectively evaluating the technical results of the claimed subject matter in comparison to the results achieved by the prior art. The next step is to determine whether the prior art suggested the claimed solution to the problem. This suggests that the problem-and-solution approach is effectively mandatory.⁷¹⁸

The three-step approach starts with the (a) determination of the closest prior art; followed by (b) establishment of the objective technical problem to be solved, and finally; and (c) considering whether or not the claimed invention, starting from the closest prior art and the objective technical problem, would have been obvious to the skilled person.⁷¹⁹ The approach involves considering whether a skilled person, based on their common general knowledge and the state of the art, would have been able to arrive at the invention without the exercise of inventive activity.⁷²⁰ While Step 1 generally involves a relatively simple data analysis process, which consists of identifying relevant features and locating the closest corresponding entry within the dataset, steps 2 and particularly step 3 tend to demand a greater degree of evaluative judgment from the examiner.⁷²¹

Rule 42(1)(c) Implementing Regulations of the EPC relates to the “subjective” technical problem, which is based on the applicant’s perspective of what problem their invention solves. However, when assessing inventive step, the “objective” technical problem must be defined independently of the applicant’s claims, focusing instead on what a person skilled in the art would recognize as the relevant problem to be solved based on prior art. Thus, while Rule 42(1)(c) Implementing Regulations of the EPC emphasises a subjective view, the assessment of inventive step relies on an objective understanding of technical problems as perceived by a

⁷¹⁴ Kaisa Suominen et al., *Visser’s Annotated European Patent Convention* (Wolters Kluwer, Alphen aan den Rijn 2022) 124.

⁷¹⁵ EPO, T 1/80, 6 April 1981 (Carbonless copying paper).

⁷¹⁶ EPO, T 465/92, 14 October 1994 (*Alcan/Aluminium alloys*).

⁷¹⁷ EPO, T 939/92, 12 September 1995 (*Triazoles/AGREVO*).

⁷¹⁸ Paul Cole, ‘Inventive step-meaning of the EPO Problem and Solution Approach, and Implications for the United Kingdom - Part I’ (1998) 20(6) *European Intellectual Property Review* 215-216; see also: Giuseppe Sanseverino, ‘The Ability to Chase Down Our Dreams. Inventive Step and Artificial Intelligence’ (2018) *I Battelli del Reno* 14 et seq.

⁷¹⁹ EPO Guidelines 2025, Part G-VII, 3-5.

⁷²⁰ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 78 et seq.

⁷²¹ Hartmann C, Allan J, Hugenholtz PB, Quintais JP et al., *Trends and developments in artificial intelligence – Challenges to the intellectual property rights framework – Final report* (Publications Office of the EU 2020) <https://data.europa.eu/doi/10.2759/683128>.

notional skilled person, which has its roots in BoA case law and will be explained more in detail in Section C.IV.3.b).

During the examination procedure, the EPO may request the applicant to provide arguments and explanations regarding the state of the art, the objective technical problem solved by the invention, and the inventive step involved. However, the ultimate burden of proof lies with the EPO. Its examiners are responsible for evaluating the patent application based on the information and evidence provided by the applicant, as well as the prior art references they independently identify. If the examiners believe there is a lack of inventive step, they must provide reasoned arguments to support this conclusion. The applicant is not required to prove the existence of an inventive step but has the right to respond to and contest any objections raised by the examiner.

a) Determining the Closest Prior Art

The problem-solution approach, as employed by the EPO to assess inventive step under Article 56 EPC, begins with the identification of the closest prior art.⁷²² According to the EPO Guidelines, this is defined as the “one single reference [that] discloses the combination of features which constitutes the most promising starting point for a development leading to the invention”⁷²³ and the one that requires the fewest modifications and is intended for a similar use.⁷²⁴ It should, in principle, be directed to a similar purpose or effect, belong to the same or a closely related technical field, and require the fewest structural and functional modifications to arrive at the invention.⁷²⁵ The analysis is undertaken from the perspective of the skilled person as of the day before the filing or priority date.⁷²⁶

However, the notion of “prior art” in European patent law must be understood expansively. Contrary to what the expression “state of the art” may suggest, it does not refer to the most advanced or contemporaneous knowledge in a technical field, but encompasses everything made available to the public prior to the filing date, regardless of whether it was ever successfully implemented or is now obsolete.⁷²⁷ The subject of the patent claim is evaluated against this entirety of pre-existing knowledge, and the claimed invention is considered to involve an inventive step only if it would not have been obvious to a skilled person in light of this prior art. Once granted, the invention itself becomes part of the state of the art for future assessments.

⁷²² (Q1) What is the closest prior art?

⁷²³ EPO Guidelines 2025, Part G-VII, 5.1; still, see also: EPO, T 855/15, 10 January 2018 (*Security architecture/WONDERWARE*) (stating that if a prior art reference is considered sufficiently distant or unrelated to the invention, it should be demonstrable that the invention would not have been obvious to a person skilled in the art when taking that prior art into account).

⁷²⁴ EPO, T 606/89, 18 September 1990 (*closest prior art/Unilever*).

⁷²⁵ Ibid.

⁷²⁶ EPO Guidelines 2025, Part G-VII, 5 and 8.

⁷²⁷ Giuliana Miglierini, ‘Verso il superamento del concetto di ovvietà in campo brevettuale?’ (Fatti & Persone, 1 April 2019) <https://www.notiziariochimicofarmaceutico.it/2019/04/03/verso-il-superamento-del-concetto-di-ovvietà-in-campo-brevettuale/>.

While the procedural structure of the problem-solution approach appears to require the selection of a single, objectively determinable starting point, *Leber* has argued that such certainty is only attainable retrospectively, after the full sequence of the problem-solution approach has been completed.⁷²⁸ The problem-solution approach is characterised by an inherent structural tension: it presupposes that the most appropriate starting document can be identified *ex ante*, while in reality, the determination of whether a particular document is the “closest” can only be made after examining the distinguishing features, the formulation of the objective technical problem, and whether the claimed invention would have been obvious in view of that document.⁷²⁹

This tension underpins what *Leber* terms the “closest prior art dilemma”: the paradox that the problem-and-solution approach requires a determination which, by its nature, cannot be definitively resolved at the outset.⁷³⁰ Recognising this, the jurisprudence of the BoA has developed a more flexible approach. Although the Guidelines and case law generally favour identifying the most promising single document, they do not impose a rigid limitation to one reference. Instead, the problem-solution approach may be performed using multiple candidate documents, each of which may constitute a plausible starting point.⁷³¹ This is particularly true in interdisciplinary fields or where the invention addresses multiple “partial problems”.⁷³² In such instances, the BoA accept the use of more than one piece of prior art, each corresponding to a different aspect of the claimed invention, provided each combination is assessed objectively and without hindsight.⁷³³

Recent decisions reflect this judicial openness.⁷³⁴ While affirming the need for a logical and realistic selection of starting documents, these cases challenge a narrow interpretation of the problem-solution approach confined to a single closest prior art. The BoA has clarified that any document offering a realistic and technically plausible path to the invention may be considered. As a result, the emphasis has shifted from identifying a uniquely correct closest prior art to ensuring that all reasonable starting points are examined for obviousness. This is consistent with the core purpose of the problem-solution approach, which is not to determine the formal identity of the starting document, but to assess whether the invention is obvious in view of the relevant prior art landscape as a whole.

Moreover, EPO case law recognise that the closest prior art need not always originate from a directly related technical field.⁷³⁵ Although it should ideally relate to the same purpose or

⁷²⁸ Thomas M Leber, ‘The closest prior art in the problem solution approach - theoretical considerations and a dilemma’ (2016) *GRUR International* 337 et seq.

⁷²⁹ *Ibid.*

⁷³⁰ EPO Guidelines 2025, Part G-VII, 6; see also: Christina Gates, ‘Patenting the Life Sciences at the European Patent Office’ (2014) 4(12) *Cold Spring Harbor Perspectives in Medicine* 5-7, <https://doi.org/10.1101/cshperspect.a020792>.

⁷³¹ EPO Guidelines 2025, Part G-VII, 6; see also: Kemal Bengi and Christopher Heath, ‘Patents and Artificial Intelligence Inventions’ in Christopher Heath, Anselm Kamperman Sanders, and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 141.

⁷³² EPO Guidelines 2025, Part G-VII, 6.

⁷³³ Kathrin Fuchsle and Thorsten Bausch, ‘The Problem of the “Closest Prior Art”’ (Kluwer Patent Blog, 24 June 2020) <https://patentblog.kluweriplaw.com/2020/06/24/the-problem-of-the-closest-prior-art/>.

⁷³⁴ EPO, T 0320/15, 15 September 2016; EPO, T 0405/14, 25 September 2019 (*Self-testing sensor / William L. Smith*); EPO, T 1841/11, 3 December 2015.

⁷³⁵ EPO, T 2057/12, 9 May 2018, § 3.2.2 (and implicitly EPO, T 855/15, 10 January 2018 (*Security architecture/WONDERWARE*)).

problem, documents from more remote domains may still qualify as suitable starting points if they provide a realistic foundation for the analysis. For example, in T 2101/12, the BoA accepted a document from the legal (for example, non-technical) field as the closest prior art, illustrating that technical relevance is not determined solely by formal classification, but by the extent to which the document’s content interacts with technical means to produce a technical effect.⁷³⁶ This underscores the principle that only technical features contribute to inventive step, and non-technical elements are only relevant if they form part of a technical solution.

A further consideration in selecting the closest prior art is whether the objective technical problem derived from it is realistic and not artificially constructed. If the problem appears contrived or implausible in view of the selected starting document, the examiner may be required to choose an alternative.⁷³⁷ This reflects the EPO’s commitment to a context-sensitive approach, in which plausibility, realism, and technical coherence guide the identification of valid starting points. Where multiple plausible starting points exist, the problem-and-solution approach should be performed for each, ensuring that the invention is non-obvious from all reasonable perspectives.

Accordingly, the question of whether the problem-solution approach must begin from a single “closest” document or may accommodate several competing candidates raises deeper issues of legal doctrine and procedural practice.⁷³⁸ These issues have been the subject of extensive jurisprudence and academic commentary. Notably, decisions of the BoA have confirmed that there is no rigid limitation to one closest prior art, particularly in broad or interdisciplinary technical contexts. The EPO Guidelines explicitly acknowledge that multiple valid starting points may exist, and that the selection must be guided by realism, plausibility, and the technical framework of the invention.⁷³⁹ As *Leber* suggests, conducting multiple problem-solution approaches with different candidate documents may be not only permissible but methodologically necessary.⁷⁴⁰ The determination of the closest prior art is thus not a categorical legal classification but a functional, context-dependent inquiry central to the integrity of the problem-solution approach.

b) Establishing the Objective Technical Problem

As a second step, to determine the objective⁷⁴¹ technical problem solved by the distinctive feature(s) of the claimed solution, the differentiating elements between the prior art and the to-

⁷³⁶ EPO, T 2101/12, 24 January 2018 (*Authentication binding document with signature/VASCO*).

⁷³⁷ EPO, T 229/85, 27 October 1986 (*Etching process*).

⁷³⁸ Kathrin Fuchsle and Thorsten Bausch, ‘The Problem of the “Closest Prior Art”’ (Kluwer Patent Blog, 24 June 2020).

⁷³⁹ EPO Guidelines 2025, Part G-VII, 5.1; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 203.

⁷⁴⁰ Thomas M Leber, ‘The closest prior art in the problem solution approach - theoretical considerations and a dilemma’ (2016) *GRUR International* 339 et seq.

⁷⁴¹ The term “objective” differentiates this problem from any general technical problem outlined in the patent application’s specification. (Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 204.

be-patented invention, are examined.⁷⁴² It is determined by objectively studying “the application (or the patent), the closest prior art and the difference (also called “the distinguishing feature(s)” of the claimed invention) in terms of features (either structural or functional) between the claimed invention and the closest prior art, identifies the technical effect resulting from the distinguishing features, and then formulates the technical problem”.⁷⁴³

The challenge lies first in defining the objective technical problem to be solved in such a way that the technical purpose is clearly emphasized.⁷⁴⁴ It is essential to distinguish between the “subjective” technical problem and the “objective” technical problem. The first one is typically defined by the applicant in the patent application. It reflects the problem that the applicant believes their invention solves, often articulated in the background section of the application. The latter one, according to EPO case law, must be reformulated based on objective criteria derived from the prior art and the technical effects achieved by the distinguishing features of the claimed invention.⁷⁴⁵ The objective technical problem should not contain pointers to the claimed solution, as doing so could lead to an *ex post facto* analysis of inventive step, which is not permissible.⁷⁴⁶ The objective technical problem is formulated based on objectively established facts and should reflect the actual contribution of the invention over prior art.⁷⁴⁷

The objective technical problem is determined primarily through a process of subtraction: the examiner must compare the patent application to the nearest prior art and identify the key differences.⁷⁴⁸ This involves examining the patent (or patent application) to identify the differences in distinguishing features between the claimed invention and the closest prior art.⁷⁴⁹

According to the EPO Guidelines, the objective technical problem should be determined based on an analytical criterion that involves (a) identifying “the difference (also called “the distinguishing feature(s)” of the claimed invention, in terms of features (either structural or functional) between the claimed invention and the closet prior art”; (b) determining “the technical effect resulting from the distinguishing features”; and (c) formulating the objective technical problem based on these differences and effects. To do so, the examiner assesses the patent application against the closest prior art and identifies the differences between the two. Then, the examiner identifies the technical effect of those differences and formulates the objective technical problem accordingly.⁷⁵⁰ As a next step, the technical effect that these

⁷⁴² (Q2) What is the difference, in terms of the technical features, between the claim and the closest prior art?; (Q3) What technical effect is caused by this difference?; (Q4) What, therefore, is the objective technical problem underlying the claimed invention?

⁷⁴³ EPO Guidelines 2025, Part G-VII, 5.2.

⁷⁴⁴ EPO Guidelines 2025, Part G-VII, 5.

⁷⁴⁵ EPO Guidelines 2025, Part G-VII, 5.2.

⁷⁴⁶ Michael M Fischer, ‘The Problem and Solution Approach – Basic Case Law and Recent Development (II)’ (2016) *epi (European Patent Institute) Information* <https://information.patentepi.org/4-16/the-problem-and-solution-approach-basic-case-law-and-recent-development-%28ii%29/>.

⁷⁴⁷ The EPO allows for the reformulation of the subjective technical problem into an objective one, especially if new relevant elements or prior art are identified during examination. This ensures that the inventive step is assessed against a realistic and relevant technical challenge (EPO, Case Law of the BoA 2022, I-D.,4.4.2).

⁷⁴⁸ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 204.

⁷⁴⁹ EPO Guidelines 2025, Part G-VII, 5.2.

⁷⁵⁰ The BoA stated in decision EPO, T 229/85, 27 October 1986 (*Etching process*) § 5, that the technical problem should be formulated in a manner that does not imply or suggest elements of the solution, as incorporating aspects of the invention’s solution into the problem’s definition inevitably leads to a hindsight perspective. For further discussion on this point, see also: Mario Franzosi, ‘I requisiti di brevettabilità’ in M Franzosi and M Scuffi (eds),

variations have must be determined and the technical issue in light of that formulated.⁷⁵¹

According to the EPO, the objective technical problem accurately reflects the actual distance between the closest prior art and the invention, whereas the inventor might perceive a greater distance due to a lack of awareness of the closest prior art.⁷⁵² It is crucial that the objective technical problem is not formulated in a way that includes pointers to the technical solution. Including aspects of the solution within the problem would result in an *ex post facto* approach to evaluating the inventive step.⁷⁵³ However, this approach of the EPO to strictly separate the problem from the solution is not without controversy.

c) Obvious to the Skilled Person

In the third step the examiner assesses the obviousness of the solution.⁷⁵⁴ An invention is deemed to involve an inventive step if, in light of the existing state of the art, it would not be considered *obvious* to a person skilled in that particular field. This phrasing clearly excludes the inventor's activities or mental state from being the sole focus of the assessment, as Article 56 EPC bases the determination of an invention's qualification on a comparison between the invention's outcome and the existing state of technology.⁷⁵⁵

Applicants must highlight the differences from the closest prior art using features that contribute technically.⁷⁵⁶ The current problem-and-solution approach focuses on whether a skilled person would have proposed the claimed technical features that distinguish the invention in question. The person skilled in the art and the problems connected to it, in particular with AI in the picture, will be further discussed in Part D.

aa) The Could-Would Approach

The third and last step of the problem-and-solution approach incorporates the “could-would” approach.⁷⁵⁷ This approach requires that: (a) the invention should not be obvious without

Diritto industriale italiano (Padova 2014) 575; Sandro Hassan, ‘Descrizione brevettuale ed esposizione del problema tecnico’ (2014) *Rivista di diritto industriale* 113 et seq.

⁷⁵¹ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 24.

⁷⁵² EPO Guidelines 2025, Part G-VII, 5.2.

⁷⁵³ EPO, T 229/85, 27 October 1986 (*Etching process*).

⁷⁵⁴ (Q5) Would the skilled person solve this problem in the manner indicated on the basis of the totality of the prior art, without at any stage employing any inventive skill?

⁷⁵⁵ Jochen Pagenberg, ‘The Concept of the “Inventive Step” in the European Patent Convention’ (1974) *IIC* 161 et seq; see also: for a general discussion in the United States: Ben Hattenbach and Gavin Snyder, ‘Rethinking the Mental Steps Doctrine and Other Barriers to Patentability of Artificial Intelligence’ (2018) 19(2) *Columbia Science and Technology Law Review* 313 et seq.

⁷⁵⁶ Thomas L Lederer, ‘Patentierung im Bereich Künstlicher Intelligenz’ (2019) *GRUR-Prax* 153.

⁷⁵⁷ The focus is not on whether a skilled person could have developed the invention by adapting or altering the closest prior art, but rather on whether they would have been motivated to do so by the prior art, anticipating some improvement or benefit. It is important to distinguish a reasonable expectation of success from the mere hopeful aspiration to succeed see: EPO, T 296/93, 28 July 1994 (*HBV antigen production*); EPO, T 207/94, 8 April 1997 (*Human beta-interferon*); EPO, T 694/92, 8 May 1996 (*Modifying plant cells*); EPO, T 2/83, 15 March 1984

knowledge that *would* have led (not merely *could* have led) to the patented invention, and (b) there must be a reasonable expectation of solving the objective technical problem.⁷⁵⁸

The examiner thus considers whether the skilled person would (not just could) have arrived at the claimed solution in an obvious way, based on the prior art and the objective technical problem.⁷⁵⁹ Therefore, it must be likely that the skilled person would combine the closest prior art with other relevant disclosures, by combining the teachings of the closest prior art with another prior art or with the general teachings of the technical field of the claimed solution under examination. The additional disclosure comes from adjacent fields or belongs to common knowledge in the field.⁷⁶⁰ The closest prior art and the additional disclosure should typically come from adjacent fields, or the further disclosure should belong to common knowledge in the field. A mere deterioration and an arbitrary, non-functional change of the prior art does not constitute an inventive step.⁷⁶¹

bb) Obvious to Try and Reasonable Expectation of Success

An invention often lacks an inventive step if a specific research path is both: (a) “obvious to try”, and (b) associated with a “reasonable expectation of success” for solving the objective technical problem.⁷⁶² This two-part test is well established in EPO jurisprudence and national case law.

Importantly, even if a research approach appears straightforward in theory (“obvious to try”), unexpected difficulties in practical implementation may lower the expectation of success.⁷⁶³ In such circumstances, it cannot be assumed that the skilled person had a reasonable expectation of success.⁷⁶⁴ Conversely, the fact that a research path required considerable time and resources

(*Simethicone Tablet / Rider*); EPO, T 764/12, 18 February 2014 (*Gumlink*); see also: EPO Guidelines 2025, Part G-VII, 5.3.

⁷⁵⁸ EPO Guidelines 2025, Part G-VII, 5.3.

⁷⁵⁹ This situation can be likened to a scenario in which a development manager instructs an engineer or a team of engineers (considered experts) to further refine a product based on a functional specification. The critical question is whether the expert in this scenario would have identified the solution to the specific technical problem, possibly drawing upon information from a second prior art document, or whether they would not have reached that solution (Jelle Hoekstra, *Methodology for Paper C - Training for the European Qualifying Examination* (Deltapatents 2009) 151).

⁷⁶⁰ The concept is typically understood as a “reasonable expectation of success”. The decision emphasizes that the relevant question is not simply whether a skilled person could have inserted a barrier between the layers, but rather whether it would have done so with the expectation of achieving some improvement or advantage (see EPO, T 2/83, 15 March 1984 (*Simethicone Tablet / Rider*) § 7).

⁷⁶¹ Friedrich K Beier, ‘Zur historischen Entwicklung des Erfordernisses der Erfindungshöhe’ (1985) *GRUR Inland* 606 et seq.; Alfred W Kumm, *Vom Spezialisten zum Generalisten der Technik. Ein Wegweiser zum technologischen Denken, Analyse und Bewerten* (Haag & Herchen, Frankfurt 2003).

⁷⁶² Cesare Galli and Mariangela Bogoni, ‘Il requisito di brevettabilità dell’attività inventiva’, in C Galli and A Gambino (eds), *Codice Commentato della Proprietà Industriale ed Intellettuale* (UTET, Turin 2011) 588; Andrew V Trask, “Obvious To Try”: A Proper Patentability Standard in the Pharmaceutical Arts? (2008) 76(5) *Fordham Law Review* 2625 et seq.

⁷⁶³ Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 8.

⁷⁶⁴ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 867 (In fields where the outcomes are uncertain, the gap from the existing state of the art widens with each decision the expert must make regarding the direction of the research).

does not necessarily indicate a lack of reasonable expectation of success, especially if the work was routine.⁷⁶⁵

Established case law acknowledges that “reasonable expectations of success” are not absolute rules but factors to be considered, as noted by both the EPO and national courts.⁷⁶⁶ EPO case law distinguishes between a “reasonable expectation of success” and a mere “hope to succeed”.⁷⁶⁷ A reasonable expectation implies that a skilled person can rationally predict, based on prior knowledge, that a project will succeed within a reasonable timeframe.⁷⁶⁸ Factors affecting the expectation of success include the level of exploration in the technical field, the complexity of the objective technical problem, and practical implementation challenges. The less explored a technical field is, the harder it is to predict a successful outcome, resulting in a lower expectation of success.⁷⁶⁹ Similarly, the complexity of the objective technical problem influences the expectation of success. Easier problems generally have a higher expectation of success, while more complex problems, which may present significant challenges, have a lower expectation.⁷⁷⁰

National courts have similarly elevated the role of the “obvious to try” test. In *Actavis v ICOS*, the United Kingdom Supreme Court held that the dosage regimen claimed by ICOS lacked an inventive step, as it was the outcome of standard dose-ranging studies that the skilled team would normally undertake. The surprising nature of the result did not suffice to render the experimentation inventive. The decision highlights the principle that merely carrying out routine research steps, even where the outcome is unexpected, does not in itself amount to an inventive step. The reasoning in *Actavis*, though delivered in the context of pharmaceutical inventions, may extend to other fields as standardisation and automation increase.⁷⁷¹ The case is particularly relevant because it demonstrates how the inventive step threshold in patent law can be elevated, especially in fields where processes become routine. In the Court of Appeal judgment, Lord Justice *Kitchin* highlighted the importance of research into new and better dosage regimens and saw no policy reason to deny a patent for discovering a novel and non-obvious dosing regimen.⁷⁷² The Court’s focus was on the process leading to the invention; if the dosage was identified through more than routine experimentation, it could be patentable.⁷⁷³

⁷⁶⁵ EPO, T 333/97, 5 October 2000 (*Somatic changes/MONSANTO*); see also: Timo Minssen, ‘Meanwhile on the Other Side of the Pond: Why Biopharmaceutical Inventions That Were Obvious to Try Still Might Be Non-Obvious - Part I’ (2010) 9(1) *Chicago-Kent Journal of Intellectual Property* 84; George S A Szabo, ‘The Problem and Solution Approach in the European Patent Office’ (1995) *IIC* 457 et seq.; Colin Birss et al., *Terrell on the Law of Patents* (19th edn, Sweet & Maxwell 2020) § 12-74; Paul England, ‘Obvious to Try, One Year On’ (2009) 4(2) *JiPLP* 114; Mark A Lemley, ‘Expecting the Unexpected’ (2017) 92(3) *Notre Dame Law Review* 1369.

⁷⁶⁶ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 255.

⁷⁶⁷ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 213.

⁷⁶⁸ EPO, T 296/93, 28 July 1994 (*HBV antigen production*), § 7.4.4.

⁷⁶⁹ *Ibid.*

⁷⁷⁰ EPO, T 2168/11, 24 June 2015 (*Alzheimer’s disease beta amyloid peptide mouse model/ELAN ELI LILLY*), § 11.3; EPO, T 192/06, 6 March 2007, (*FokI endonuclease/JOHNS-HOPKINS*) § 11; EPO, T 782/07, 4 February 2009, (*Human Antibodies/WELLCOME*) § 35.

⁷⁷¹ *Actavis Group PTC Ehf and others v ICOS Corporation and another* [2019] UKSC 15.

⁷⁷² *Actavis Group PTC Ehf v ICOS Corporation* [2016] EWHC 1955 (Pat).

⁷⁷³ Kristina Cornish, ‘Actavis v ICOS - The Supreme Court rules on Dosage Regimes’ (Kilburn & Strode, 27 March 2019) <https://www.kilburnstrode.com/knowledge/european-ip/actavis-v-icos-the-supreme-court-rules>.

However, if it was the result of standard, “obvious-to-try” investigation, it would not be. This case illustrates how the court can raise the bar for the inventive step, especially for dosage optimization claims, as these become obvious-to-try.

cc) Try-and-See Scenarios

The EPO also recognizes “try-and-see” scenarios as a variation of the “obvious to try” approach. In these situations, if implementing and testing a prior art approach involves no particular technical challenges, there is no need to assess whether the skilled person had a reasonable expectation of success. Instead, the skilled person would verify if the potential solution works by trying it out, rather than abandoning the project due to uncertainty.⁷⁷⁴

At first glance, the “try-and-see” approach may seem to contradict the principle that a mere “hope to succeed” is not enough to negate an inventive step. However, this approach can be aligned with the “obvious to try” test by recognizing that “try-and-see” assumes the skilled person expects no difficulties in implementation and testing, involving routine procedures. In such cases, the unpredictability of the result is insufficient to dismiss a lack of an inventive step, as the skilled person would still have some expectation of success. The BoA has emphasized that a “try-and-see” attitude does not mean there is no reasonable expectation of success.⁷⁷⁵

dd) The Evaluation of the Technical Merits through the Reproducibility Test

The evaluation of the technical merit of an invention can be supplemented with the “reproducibility test”, which measures the ease with which an invention can be replicated within a reasonable time, thereby offering a more objective criterion without relying on the hypothetical question of whether a person having ordinary skill in the art would have easily conceived the invention.⁷⁷⁶

While reproducibility can supplement an evaluation of the technical merit of an invention, it cannot replace it.⁷⁷⁷ Focusing solely on reproducibility would undermine the disclosure function of the patent system, which is ensured by comprehensible patent specifications that can be understood by the skilled person.⁷⁷⁸

⁷⁷⁴ EPO, T 259/15, 25 July 2017 (*Buprenorphine patch/EURO CELTIQUE*).

⁷⁷⁵ EPO, T 1396/06, 31 May 2007 (*HLA Binding Peptides/EPIMMUNE*).

⁷⁷⁶ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 42; Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 106.

⁷⁷⁷ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 150 et seq.

⁷⁷⁸ Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 322; Robert Plotkin, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business* (Stanford University Press 2009) 159.

d) Secondary Indicia

In addition to the three steps of the problem-solution approach, the EPO may also consider so-called secondary indicia, namely, supplementary indicators or factors, that can support or challenge the presence of an inventive step.⁷⁷⁹ The secondary indicia in the assessment of the inventive step are elaborated in the EPO Guidelines and provide additional guidance on the examination of the inventive step.⁷⁸⁰ While they are not conclusive proof of an inventive step, these indicia can support the argument that the claimed invention is not obvious in light of the prior art. This helps mitigate the prejudice that may arise from an *ex post facto* analysis, leading to a more objective assessment based on the circumstances at the time of the invention.⁷⁸¹

Secondary indicia therefore serve as mere supplementary factors (literally, “secondary”) in assessing an inventive step⁷⁸² and are only significant when there is uncertainty in objectively evaluating the invention’s inventiveness.⁷⁸³ Although there is disagreement over the appropriate weight to assign to secondary indicia in the inventive step analysis, most scholars, including the BoA, agree that they should only be used to support findings or in cases of uncertainty.⁷⁸⁴

Indicia of an inventive step can be categorized based on their support for the inventive step of an invention. These indicators can be focused in three directions: (a) technical characteristics (the specific features of the invention and the inventive process); (b) historical context (the state of the field prior to the invention, including non-obvious clues such as overcoming specific difficulties, previous unsuccessful attempts, and the satisfaction of long-standing needs); (c) post-invention events (developments that occurred in the field after the invention, such as commercial success, expert opinions, or competitor behaviour). Examining the relevant field prior to the invention can reveal non-obvious clues that demonstrate the inventor’s solution was not apparent to others in the sector. Conversely, indicators from after the invention, such as

⁷⁷⁹ See Ana Ramalho, ‘Patentability of AI-Generated Inventions’ (2021) *GRUR International* 15 et seq; Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 685.

⁷⁸⁰ EPO Guidelines 2025, Part G-VII, 10; see also: Mario Franzosi, ‘I requisiti di brevettabilità’ in M Franzosi and M Scuffi (eds), *Diritto industriale italiano* (Cedam 2014) 323.

⁷⁸¹ In the United States, the initial approach to patent evaluation prioritized a technical analysis of the invention, focusing on primary considerations. If there were uncertainties about the invention’s inventiveness, secondary considerations were then examined, viewed as supplementary but less critical. However, it is now recognized that secondary considerations must always be part of the analysis. The term “secondary” merely indicates the sequence in which these factors are considered, not their significance. Some experts argue that secondary considerations are, in fact, crucial and may be the definitive evidence of an invention’s inventive value. (Anthony Colaizzi, ‘35 USC § 103: A Quest for Objectivity’ (1981) *Intellectual Property Law Review* 212; Irving R Kayton, ‘Nonobviousness of the Novel Invention - 35 USC § 103’ in John F Witherspoon (ed), *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs, Washington 1979); Giles S Rich, ‘Laying the Ghost of the “Invention” Requirement’ (1972) 1(26) *APLA Quarterly Journal* 38 et seq.).

⁷⁸² T 1072/92, Reason 3.5 § 2.

⁷⁸³ T 0877/99, Reason 3.6.4.

⁷⁸⁴ This is also the position of the BoA (EPO, Case Law of the BoA 2022, I-D., 10.1 (“[s]econdary indicia [of non-obviousness] are only of importance in cases of doubt, for example, when objective evaluation of the prior art teachings has yet to provide a clear picture”); see also: Mario Franzosi, ‘I requisiti di brevettabilità’ in M Franzosi and M Scuffi (eds), *Diritto industriale italiano* (Cedam 2014) 323; Cesare Galli and Mariangela Boggi, ‘Il requisito di brevettabilità dell’attività inventiva’, in C Galli and A Gambino (eds), *Codice Commentato della Proprietà Industriale ed Intellettuale* (UTET, Turin 2011) 578 et seq.; Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 699.

commercial success, can also provide evidence of non-obviousness.⁷⁸⁵ However, these indices are not considered “primary” as they depend on the technical assessment of the invention.

The *ex post* assessment of these indicia must consider the absence of explicit regulatory recognition and should not lead to unequal treatment of inventions based on the timing of the assessment. The absence of positive indicia can be considered an independent (negative) sign of the inventiveness of the invention.⁷⁸⁶

According to the Case Law of the BoA,⁷⁸⁷ secondary indicia include:

- (a) the evidence that a known technical prejudice needs to be overcome;⁷⁸⁸
- (b) the age of documents and the existence of an unsolved problem during the period between the documents and the invention (time factor);⁷⁸⁹
- (c) the satisfaction of a long-felt but unresolved need, especially when the state of the art has been inactive prior to the invention;⁷⁹⁰
- (d) particularly commercial success combined with evidence of a long-standing need,⁷⁹¹ where the commercial success derives from the technical elements of the invention and not from contingent and accessory situations, such as effective marketing campaigns;⁷⁹²
- (e) efforts by market competitors to obtain rights of joint use;⁷⁹³
- (f) the simplicity of a proposed solution in a commercially important technical field;⁷⁹⁴
- (g) a surprising result or bonus effect considering the prior art.⁷⁹⁵

The application thereof to AI-related inventions will be later discussed in Section G.I.4.b).

⁷⁸⁵ The indicators can be useful in uncertain cases, offering supportive arguments for conclusions already drawn using the problem and solution approach (Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 127).

⁷⁸⁶ Vincenzo Di Cataldo, *L’originalità dell’invenzione* (Giuffrè 1983) 91.

⁷⁸⁷ EPO, Case Law of the BoA 2022, I-D,10.2; Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 125.

⁷⁸⁸ EPO, T 631/89, 10 April 1992; EPO, T 695/90, 31 March 1992; EPO, T 1212/01, 3 February 2005 (*Pyrazolopyrimidinones for the treatment of impotence/PFIZER*).

⁷⁸⁹ EPO, T 79/82; 6 October 1983; EPO, T 0295/94, 26 July 1994.

⁷⁹⁰ Guy Tritton et al., *Intellectual Property in Europe* (2nd edn, Sweet & Maxwell 2002) 97-98; see also: EPO, T 109/82, 15 May 1984 (*Hearing aid/Bosch*); EPO, T 255/91, 12 September 1991 (*Priority*); EPO, T 699/12, 13 November 2017.

⁷⁹¹ EPO, T 106/84, 25 February 1985 (*Packing machine*); EPO, T 110/92, 12 October 1994; EPO, T 478/99, 7 December 2000; EPO, T 1212/01, 3 February 2005 (*Pyrazolopyrimidinones for the treatment of impotence/PFIZER*); EPO, T 677/91, 3 November 1992 (*Mass selective ejection/FINNIGAN*); EPO, T 626/96, 10 January 1997 (*Commercial success/water tap*).

⁷⁹² Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 412.

⁷⁹³ EPO, T 128/92, 30 November 1994; EPO, T 351/93, 1 March 1995; EPO, T 252/06, 6 May 2008.

⁷⁹⁴ EPO, T 106/84, 25 February 1985 (*Packing machine*); see also: EPO, T 229/85, 27 October 1986 (*Etching process*).

⁷⁹⁵ EPO, T 0181/82, 28 February 1984 (*Spiro compounds*); Andrea Ottolia, ‘Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30’, in L C Ubetazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (7th edn Wolters Kluwer 2019) sub art. 48 CPI.

e) Critique of the Problem-and-Solution Approach

The EPO has applied the problem-and-solution approach as a tool against inconsistencies in patent examination at a point when the need for consistency was considered more important than any pragmatism.⁷⁹⁶ The aim of this approach is to provide a predictable outcome for patent applicants, making it easier for them to navigate the patent examination process.⁷⁹⁷ Focusing on a single piece of prior art as the closest reference is particularly beneficial for the EPO's administrative procedures.⁷⁹⁸

Although the EPO largely follows this approach, it takes into consideration also less artificial and more technically realistic criteria for proper application.⁷⁹⁹ The approach is also challenging to apply to “problem inventions”, where the invention lies in identifying the problem, and the solution becomes obvious once the problem is recognized.⁸⁰⁰ In such cases, once the problem is articulated, the solution may appear straightforward or even obvious, which complicates the assessment of inventiveness under the traditional framework.

The rigid conceptual separation between problem and solution inherent in the EPO methodology has been the subject of ongoing critique. It can be argued that, in practice, this separation is difficult to maintain, as the identification of the problem and its resolution are often inextricably linked within the inventive process. Reflecting this criticism, Germany's Federal Court of Justice's (BGH) has adopted a more flexible approach that acknowledges the interdependence between the problem and its solution.⁸⁰¹ The Court has explicitly distanced itself from the formalism of the EPO's methodology, favouring an analysis that captures the inventive merit in its entirety.

Nonetheless, for the purpose of drafting and prosecuting European patent applications, it remains essential to conform to the EPO's problem-and-solution approach. Applicants are advised to structure the application accordingly. This may include presenting multiple

⁷⁹⁶ Still, the EPO was sometimes criticised for following the approach to literally (see for example EPO, T 939/92, 12 September 1995 (*Triazoles/AGREVO*); EPO, T 20/81, 10 February 1982 (*Aryloxybenzaldehydes*)).

⁷⁹⁷ George S A Szabo, ‘The Problem and Solution Approach in the European Patent Office’ (1995) *IIC* 457 et seq.

⁷⁹⁸ Justine Pila, *The Requirement for an Invention in Patent Law* (OUP 2010) 174-175; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 207.

⁷⁹⁹ The approach has also been criticized for being “unnecessarily artificial”, since many inventions are not developed with a specific problem in mind. (Lionel Bently et al., *Intellectual Property Law* (5th edn, OUP 2018) 581; Justine Pila, *The Requirement for an Invention in Patent Law* (OUP 2010) 175.

⁸⁰⁰ Although both the EPO and the USPTO recognize “problem inventions”, where the inventive step lies in identifying a previously unrecognized problem, this approach is outdated and not compatible with the problem-and-solution approach. The BoA emphasized that inventive step is present when the formulation of the problem itself was non-obvious (see EPO, T 1236/03, 8 March 2006; EPO, T 109/82, 15 May 1984 (*Hearing aid/Bosch*)). The Guidelines also highlight that the question is not whether a skilled person *could* have arrived at the solution, but whether they *would* have done so, motivated by an expectation of improvement (EPO Guidelines 2025, Part G-VII, 5.3; see also: *Actavis UK Ltd v Novartis AG* [2010] EWCA Civ 82).

⁸⁰¹ For the approach of the German Federal Court of Justice see: Malte Köllner, ‘Zur Prüfung der erfinderischen Tätigkeit nach deutschem Recht’ (2023) *Mitteilungen der deutschen Patentanwälte* 202 et seq.; relevant case law: BGH, Judgment of 15 November 1983, X ZR 27/82 *Kreiselegge* [1984] GRUR 194; BGH, Judgment of 13 January 2015, X ZR 41/13 *Quetiapin* [2015] GRUR 352; BGH, Judgment of 11 November 2014, X ZR 128/09 *Repaglinid* [2015] GRUR 356.

formulations of the objective technical problem and ensuring a clear distinction between the technological background and the claimed solution.

Moreover, the EPO itself has acknowledged scholarly criticisms of the method and has clarified that the problem-and-solution approach is not a *condicio sine qua non*, nor the exclusive standard for evaluating inventive step.⁸⁰² While it remains the default and most widely applied framework, this acknowledgement opens the door for some interpretive flexibility, particularly in complex or unconventional cases.

In the 1990s *Alcan v Aluminium* case it was highlighted that the problem-and-solution approach should be viewed as one of several potential methods, each with its own strengths and weaknesses.⁸⁰³ An opponent should not be restricted to selecting one piece of prior art as the closest, risking failure if the BoA disagrees with their choice. A significant issue identified in *Alcan v Aluminium* is that the problem-and-solution approach is “inherently based on hindsight” as it relies on the results of a search for the closest prior art and the objective technical problem determined with knowledge of the invention.⁸⁰⁴ This assessment presents a series of questions that risk burdening the judgement with subjective considerations, since it is necessarily made *a posteriori*, leading to considerable discretion for the interpreter.⁸⁰⁵

f) Challenges for the Applicability to AI-Related Inventions

The application of the problem-and-solution approach faces unique challenges with AI inventions, especially those falling under Category IV-V.

Importantly, the formulation of the objective technical problem (step 2) must remain grounded in technical effects that are credibly achieved by the claimed invention. In AI-related cases, this may require applicants to clearly specify the technical contribution of the AI system, supported by objectifiable parameters or testable outcomes, to avoid *ex post facto* problem definitions. For instance, where an AI model contributes to improved performance in image recognition or drug compound selection, this must be demonstrable and linked to verifiable technical advantages over the prior art (step 1).

In a preliminary analysis it could be states that in Category IV inventions, where AI systems are utilised as tools to enhance the inventor’s capacity to explore technical problem spaces, by accelerating the process of identifying potential solutions, AI may facilitate scenarios that could be regarded as “obvious to try” (step 3). In applying the problem-solution approach, EPO examiners must be cautious when determining whether the skilled person, now potentially equipped with similar AI tools, would have been motivated to arrive at the claimed invention

⁸⁰² Jean-François Portal, ‘Contribution à une Nouvelle Analyse de l’Approche Problème-Solution’ (1995) 2 *epi (European Patent Institute) Information* 69.

⁸⁰³ EPO, T 465/92, 14 October 1994 (*Alcan/Aluminium alloys*).

⁸⁰⁴ *Ibid.*, § 9.5.

⁸⁰⁵ Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 121; Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 169; Maurizio Ammendola, *La Brevettabilità nella Convenzione di Monaco* (Giuffrè 1981) 169; Vincenzo Iaia, ‘Le Invenzioni. L’oggetto e i Requisiti di Brevettabilità’ in F Genovese and G Olivieri (eds), *Proprietà Intellettuale* (UTET 2021) 450.

with a reasonable expectation of success. This may result in raising the bar for inventive step, as the availability and use of AI tools could render certain solution paths foreseeable or derivable through routine application of such technologies.

Especially in Category V inventions, where the invention is claimed to have been autonomously generated by an AI system, the EPO encounters a more complex evaluative problem. When the invention's development pathway is not fully transparent, due to the opaque or "black box" nature of AI systems, examiners may struggle to determine whether the claimed invention truly involves an inventive contribution beyond the prior art.

Both Category IV and Category V inventions must be assessed case-by-case, ensuring the AI entity is not named as the inventor to proceed to the inventive step examination.⁸⁰⁶ These considerations have already inspired the interpretation of patentability requirements. The United States Supreme Court stated some time ago that the non-obviousness analysis must be flexible and "susceptible to case-by-case development"⁸⁰⁷ and more recently that a non-obviousness assessment must take into account also modern technologies.⁸⁰⁸

Nonetheless, the problem-solution approach remains applicable: the analysis must still ask whether, from the perspective of a skilled human practitioner (not the AI system), the claimed invention would have been obvious.

4. Challenges in Assessing the Inventive Step in AI-Related Inventions

In order to address the complexities introduced by AI in the assessment of inventive step effectively, the discussion must be organised around specific legal issues. This structured approach clarifies the specific points at which AI-related inventions may encounter difficulties in the patent examination process within the framework of the EPC.

The first set of issues relates to the concept of the person skilled in the art, specifically the definition, tools and techniques at disposal, and the connected knowledge. These considerations are fundamental to determining whether an invention is obvious, particularly when the inventive contribution originates from AI systems that operate beyond typical human capabilities (see Part D).

A second core issue concerns the identification and assessment of the prior art, including what constitutes relevant art for the purposes of determining obviousness. The unique nature of AI-related outputs can complicate this analysis, particularly when prior disclosures do not clearly anticipate or suggest the invention, due to the non-human problem-solving pathways of AI (see Part E).

⁸⁰⁶ Jochen Ehlers et al., 'European Patent Office', in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 109.

⁸⁰⁷ *Graham v John Deere Company* 383 US 1, 11 (1966) (US Supreme Court).

⁸⁰⁸ Ana Ramalho, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 25 et seq.

A third, closely related concern is the sufficiency of disclosure. This requires the patent application to enable a person skilled in the relevant field to carry out the invention without undue difficulty. In the context of AI, this raises questions about the degree of transparency required, particularly where machine learning models or datasets are involved, and whether the disclosed information is sufficient to reproduce the claimed technical effect (see Part F).

Taken together, these three areas form the core analytical pillars for examining inventive steps in AI-related inventions. Each area presents distinct legal and practical challenges that merit detailed consideration.

5. Preliminary Results

The inventive step is a critical requirement in most patent systems, ensuring that an invention is not only novel but also represents a significant advancement beyond prior art. The assessment of what constitutes an inventive leap varies across jurisdictions, reflecting both historical and modern approaches to patent law. Historical precedents, such as the Venetian Inventor's Statute and the US case *Hotchkiss v Greenwood*, have laid the groundwork for the contemporary understanding of the inventive step.

Under the EPC, the inventive step is a key criterion for patentability, assessed objectively based on what a person skilled in the art would find obvious given the prior art. The EPC does not clearly define “obviousness” or “person skilled in the art”, leaving these determinations to the EPO and its BoA. The EPO's problem-and-solution approach is a structured method for assessing the inventive step, involving (a) identifying the closest prior art, (b) establishing the objective technical problem, and (c) assessing obviousness. This approach was introduced to promote consistency in patent examination, offering procedural predictability by focusing (mostly) on a single piece of closest prior art. While administratively efficient, the method faces criticism for its rigidity-particularly in cases of “problem inventions”, where identifying the problem is itself the inventive step. Critics argue that the strict separation between problem and solution is artificial, as these elements are often interdependent. Although the EPO continues to apply the approach as the standard, it acknowledges that it is not mandatory and may be supplemented or adapted in complex cases. Nonetheless, applicants are still advised to structure their applications in line with the EPO framework.

Applying the problem-and-solution approach to AI-related inventions presents challenges. Applicants must clearly identify and support the technical contribution of the AI system with verifiable outcomes, in order to avoid relying on retrospective justifications. In Category IV, the use of such tools may make some inventions appear “obvious to try”, which could potentially raise the bar for an inventive step. In Category V, the opaque nature of AI makes it difficult to assess whether a genuine inventive step exists. Despite these complexities, the EPO continues to apply the problem-and-solution approach, maintaining the perspective of a human skilled in the relevant field. Three key issues must be examined to navigate this: the definition and capabilities of the skilled person; the identification of relevant prior art; and the sufficiency of disclosure, particularly in light of AI's technical opacity and the reproducibility of its outputs.

D. AI AND THE PERSON SKILLED IN THE ART

I. The Person Skilled in the Art in Patent Examination

The process of assessing the inventive step involves determining who the person skilled in the art is, as well as what the common general knowledge in that field is. Then, the inventive step must be established by distinguishing the invention from the state of the art. The final step is to determine if the differences between the state of the art and the claimed invention are self-evident to the skilled person, or if they necessitate some level of “invention”.

1. General Legal Relevance of the Person Skilled in the Art

The person skilled in the art plays a critical role in multiple aspects of patent law. In legal terms, the person skilled in the art acts as a neutral and objective measure. In the practice of the EPO, it represents the hypothetical “regular” professional within the relevant field who aids in constructing an objective judgment of the technical advancements related to the invention.⁸⁰⁹ Initial drafts of the EPC did not incorporate the notion of a person skilled in the art; instead, they described an invention as involving an inventive step if it was not obvious in light of the state of the art. The concept of the person skilled in the art was later introduced to provide an objective legal fiction and avoid subjective application of the standard by patent examiners, due to concerns from some EPC Member States.⁸¹⁰

The patentee is required to provide enough information to enable a skilled person to carry out the invention “without undue burden”.⁸¹¹ However, the disclosure only concerns the invention itself and the research and development process or tools are generally not mentioned.⁸¹² Article 83 EPC mandates that a European patent application disclose the invention clearly and completely enough for it to be carried out by, once again, the person skilled in the art. Moreover, the Protocol on the Interpretation of Article 69 EPC mentions the person skilled in the art as the standard for interpreting patent claims.⁸¹³ Therefore, the law requires that the assessment of the inventive step, sufficiency of disclosure, and infringement analysis be anchored to this hypothetical model of the skilled person.⁸¹⁴

⁸⁰⁹ EPO, T 422/93, 21 September 1995 (*Luminescent security fibres/ JALON*); see also: Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁸¹⁰ Klaus Pfanner, ‘Vereinheitlichung des materiellen Patentrechts im Rahmen des Europarats’ (1962) *GRUR Ausland* 553; Martin Van Empel, *The Granting of European Patents* (Berlin and Heidelberg 1973) 89 et seq.; Jochen Pagenberg, ‘Article 56’ in F K Beier, K Haertel and G Schricker (eds), *MünchKer Gemeinschaftskommentar, EPÜ* (Carl Heymanns, Cologne 1984) § 5 et seq.

⁸¹¹ EPO, T 32/85, 5 June 1986, § 5.

⁸¹² Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 31.

⁸¹³ Protocol on the Interpretation of Article 69 of the EPC of 5 October 1973, as revised by the Act revising the EPC of 29 November 2000.

⁸¹⁴ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 173.

Whether an invention was reached through pure luck or with a lot of effort, such as through the use of AI models or calculations on paper, is not relevant since the focus is on the objective assessment of whether a skilled person with average knowledge and tools would have arrived at the same solution, given the prior art and the objective technical problem at hand.⁸¹⁵ The analysis of the inventive step hinges on contrasting the state of the art with the claimed invention by the patentee. This evaluation does not concern the personal ease or difficulty encountered by the inventor in reaching the solution, nor does it consider the inventor's perception of having made an inventive breakthrough.⁸¹⁶ The main point is that the focus is on whether the invention meets the objective standard of the inventive step based on the prior art and the objective technical problem, rather than on the inventor's personal circumstances or subjective reasoning behind the invention.

2. The Identity and Knowledge of the Person Skilled in the Art

The person skilled in the art (often abbreviated as skilled person, PSITA or PHOSITA) serves as a central reference point in patent law to assess the inventive merit of the claimed invention.⁸¹⁷ While the EPC does not explicitly define the skilled person, it provides guidance on the expected skills and knowledge. The concept of person skilled in the art originates from early case law of the BoA and has been consistently applied in EPO practice. According to the EPO Guidelines the skilled person is “a skilled practitioner in the relevant field of technology who is possessed of average knowledge and ability (average skilled person)”.⁸¹⁸ This individual possesses average knowledge and ability and is aware of what was common general knowledge in the art at the relevant date.⁸¹⁹ This individual is “to have had access to everything in the “state of the art”, in particular the documents cited in the search report, and to have been in possession of the means and capacity for routine work and experimentation which are normal for the field of technology in question”.⁸²⁰

⁸¹⁵ Noam Shemtov, ‘A study on inventorship in inventions involving AI activity’ (Commissioned by the EPO, February 2019) 35; Sven Hetmank and Anne Lauber-Rönsberg, ‘The Concept of Authorship and Inventorship Under Pressure: Does Artificial Intelligence Shift Paradigms?’ (2019) 14(7) *JIPLP* 571 et seq.; Stefan Luginbühl, ‘Patent Protection of Inventions Involving Artificial Intelligence’ in *Transition and Coherence in Intellectual Property Law: Essays in Honour of Annette Kur* (Cambridge University Press, Cambridge 2021) 196 et seq.; William Cornish, David Llewelyn and Tanya Aplin, *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights* (9th edn, Sweet & Maxwell 2013) 5 et seq.

⁸¹⁶ Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 401; Mario Franzosi, ‘Non ovvietà’ in *Studi di diritto industriale in onore di Adriano Vanzetti* (Giuffrè 2004) 567-568; Phillip Rektorschek and Tobias Baus, ‘Protectability and Enforceability of AI-Generated Inventions’ in K Jacob, D Schindler and R Strathausen (eds), *Liquid Legal, Towards a Common Legal Platform* (Berlin and Heidelberg 2020) 467.

⁸¹⁷ EPO Guidelines 2025, Part G-VII, 5.1; a recent BoA decision suggested that the skilled person should be established after the objective technical problem has been formulated (EPO, T 1450/16, 17 January 2020 (*Acoustic port of a hearing device/SHURE*)); Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 25.

⁸¹⁸ EPO Guidelines 2025, Part G-VII, 3.

⁸¹⁹ This standard is similar to other legal standards that use hypothetical notional persons, such as the “reasonable person” or “average consumer” (Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 17).

⁸²⁰ EPO Guidelines 2025, Part G-VII, 3.

In the practice of the EPO, the skilled person is not a fictitious someone who is outstanding or faultless, but typically a professional active in the technical field at the time of filing. This persona is not an inherently inventive individual but one capable of demonstrating a certain level of innovation.

Although the skilled person remains consistent in representing specific legal standards, its identity can be adjusted according to the purpose served at any given time. For example, while the state of the art is considered from a global perspective, the skilled person is viewed in the context of a typical practitioner within a specific geographical area.⁸²¹ Thus, while the state of the art imposes a worldwide perspective, the absence of a similar provision with reference to the person skilled in the art means that the average practitioner in that specific geographical area must be considered. This encompasses everything that falls under common general knowledge and enhanced knowledge⁸²² on the day before the priority date for the claimed invention. This construct ensures that the inventive step is assessed without the influence of hindsight, as it focuses on what would have been obvious to the skilled person at the time of the invention's priority date.⁸²³

The skilled person is therefore aware of what was common general knowledge at the relevant date and has the standard skills obtained through education and experience, which enable it to carry out routine tasks, research and conduct experiments, while also seeking help from specialists when needed, and follow any available suggestions.⁸²⁴ It is able to make immediate logical associations between solutions found in the known technique and routine work.⁸²⁵ This denotes that while it may not be exceptionally skilled or knowledgeable, the level of expertise is typical for someone practically oriented working in the field. It is not a unitary figure that is independent of the function it is called upon to perform, but changes depending on the purpose it is serving at the time. Still, the person skilled in the art is not creative: it can connect different information but not come up with new ideas and therefore “knows everything yet imagines

⁸²¹ Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 409; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁸²² Tribunale di Milano, specialised section, 11 December 2017, n. 12377, in *De Jure* (stating that as a general rule, the skilled person can be correctly identified as a technician who is active in the relevant field and possesses an average level of expertise in that field. This includes knowledge of both the basic and fundamental technical concepts that constitute the common general knowledge (common-general knowledge) and the more advanced knowledge acquired to solve a new problem, which encompasses relevant patents and current literature (enhanced-knowledge); see also: Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

⁸²³ It is, therefore, essential to capture the state of technological development and scientific progress as they existed at the specific historical moment when the patent application was filed (EPO Guidelines 2025, Part G-VII, 5.1; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.; Gustavo Ghidini and Fabrizio De Benedetti, *Codice della Proprietà Industriale - Commento alla normativa sui diritti derivanti da registrazione e brevettazione* (Giuffrè 2006) 137.

⁸²⁴ Bardehle Pagenberg, ‘Assessment of Inventive Step under the EPC’ (2021) https://media.bardehle.com/contentdocuments/broschures/Assessment_of_Inventive_Step_under_the_EPC.pdf.

⁸²⁵ In evaluating the inventive step, the relevant skilled technician is the one who reinterprets the existing technical heritage, focusing only on making obvious connections between the pertinent prior art (see: Tribunale di Milano, specialised section, 5 October 2018, n. 9889, (2018) *Giurisprudenza annotata di diritto industriale* 1017).

nothing”⁸²⁶ and can therefore not be an inventor.⁸²⁷ The person skilled in the art “shows no such innovative tendency but is simply a user of the technology”.⁸²⁸

This individual can refer to the existing state of the art, consult other experts when necessary, and follow available guidance or recommendations.⁸²⁹ The skilled person is presumed to have access to all prior art in the relevant technical field and is expected to consult prior art from neighbouring fields. However, it typically does not consider prior art from remote technical fields unless there is a compelling reason to do so.⁸³⁰ According to EPO case law, such as in T 855/15, it has been established that the remoteness of a piece of prior art does not automatically rule it out for assessing inventive step.⁸³¹ If there are compelling reasons or evidence suggesting that a skilled person might consider a remote document, it can still be relevant. The assessment must be based on whether there are realistic circumstances that would lead a skilled person to give attention to that prior art, rather than relying solely on speculation.

The skilled person is not a static entity but one whose level of competence and expertise varies depending on the specific branch of technology involved in the case.⁸³² For example, when an invention spans multiple fields, the skilled person may be seen as a team of experts, such as a machine learning specialist and an aerospace engineer.⁸³³ In certain complex fields or rapidly evolving technologies, the skilled person may embody the collective skillset of an entire team of specialists.⁸³⁴ The BoA has recognised that in cases where new technology is being incorporated into an existing field, the skilled person might consist of experts from relevant technological areas.⁸³⁵ For example, in an invention involving computers in orthodontics, the skilled person could include orthodontists, a computer-aided design expert, and a computer-aided manufacturing expert.⁸³⁶ The determination of this skilled person is crucial, as it sets the benchmark for assessing the inventive step of an invention.

⁸²⁶ Kemal Bengi and Christopher Heath, ‘Patents and Artificial Intelligence Inventions’ in Christopher Heath, Anselm Kamperman Sanders, and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 141 et seq.

⁸²⁷ EPO, T 39/93, 14 February 1996 (*Polymer powders/ALLIED COLLOIDS*) (“he is the expert in the relevant field, who is possessed of average knowledge and ability, i.e. not an exceptional, outstanding or brilliant expert”); see also: Tribunale di Venezia, 13 October 2009, in *Giurisprudenza Annuale di Diritto Industriale* 2009, 1231, where it is stated that ‘the person skilled in the art [...] is a person with a high degree of technical experience, but is not an inventor’; EPO, T 475/88, 23 November 1989.

⁸²⁸ Dan L Burk and Mark A Lemley, ‘Is Patent Law Technology-Specific?’ 17(4) *Berkeley Technology Law Journal* (2002) 1190.

⁸²⁹ Bardehle Pagenberg, ‘Assessment of Inventive Step under the EPC’ (2021) https://media.bardehle.com/contentdocuments/broschures/Assessment_of_Inventive_Step_under_the_EP_C.pdf.

⁸³⁰ See for example EPO, T 2101/12, 24 January 2018 (*Authentication binding document with signature/VASCO*); EPO Guidelines 2025, Part G-VII, 3; Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 26.

⁸³¹ EPO, T 855/15, 10 January 2018 (*Security architecture/WONDERWARE*).

⁸³² EPO, Case Law of the BoA 2022, I-D, 8.1.2; EPO Guidelines 2025, Part G-VII, 3; see also: Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 18; Mark A Lemley and Dan L Burk, ‘Policy Levers in Patent Law’ 89 *Virginia Law Review* (2003) 1581.

⁸³³ Heli Pihlajamaa, ‘Assessing inventive step: Problem-solution approach’ (EPO, 21 February 2020) 4.

⁸³⁴ EPO, T 60/89, 31 August 1990 (*Fusion Proteins*); EPO, T 500/91, 21 October 1992 (*Alpha-interferon II/BIOGEN*).

⁸³⁵ EPO, T 15/15, 16 March 2017, § 4.4.

⁸³⁶ *Ibid* (the Board noted that during the early 1990s, the adoption of computers for planning and manufacturing processes was rapidly spreading across various industries and technological fields, including dentistry and orthodontics. Professionals in these fields recognized the potential of this emerging technology to improve quality

Thus, the skilled person is typically a professional active in the technical field at the time of filing, characterised by a comprehensive understanding of all prior art, a complete capacity for logical reasoning, and a common problem-solving ability essential for reconstructing the state of the prior art.⁸³⁷

3. The Role of the Skilled Person in Assessing the Inventive Step

The person skilled in the art is instrumental in the evaluation of inventive step. The EPC requires that the assessment of an inventive step be carried out from the viewpoint of this “hypothetical individual” who is knowledgeable in the relevant field and is presumed to be aware of all the pertinent prior art.⁸³⁸ This individual’s perspective serves as an interpretative tool for objectively judging the technical contributions of an invention. Thus, the person skilled in the art is a tool used to evaluate the necessary level of inventiveness, representing the group of potential inventors within the existing paradigm of human inventorship. If the group of potential inventors were to be extended to include AI systems, patent law could use a different legal fiction as a measuring device without any justification.⁸³⁹

Each situation calls for a different level of competence and expertise that the skilled person should possess, which is determined on a case-by-case basis by considering the relevant branch of technology and means at disposal.⁸⁴⁰

The normative definition of the inventive step for an expert in a particular field encompasses three distinct elements that require a separate analysis.

and reduce costs. It was common practice, in such circumstances, to form development teams that combined expertise from both the traditional and new technological fields, facilitating the integration of new technologies into established practices.); see also: Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.

⁸³⁷ The term ‘expert’ typically refers to an individual with the practical experience of an operator in the relevant technical field, rather than a scholar or consultant (though some opinions may differ). This expert is expected to be familiar with all prior art and possess a thorough capacity for reasoning. However, they are not expected to have exceptional intuitive abilities, but rather a standard problem-solving capability, particularly when it comes to reconstructing the state of prior art (Maurizio Ammendola, *La brevettabilità nella convenzione di Monaco* (Giuffrè 1981) 159 et seq.; Martin Van Empel, *The Granting of European Patents* (Berlin and Heidelberg 1973) 47 et seq.; Paul Mathely, *Le droit européen des brevets d’invention* (Journal des notaires et des avocats 1978) 123; Vincenzo Di Cataldo, ‘I brevetti per invenzione e per modello di utilità. I disegni e modelli’ in P Schlesinger (ed), *Commentario al codice civile* (Giuffrè 2012) 106; Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 139).

⁸³⁸ Maurizio Ammendola, *La brevettabilità nella convenzione di Monaco* (Giuffrè 1981) 135-136; Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 10.

⁸³⁹ Martin Stierle, ‘A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System’ (2021) *GRUR International* 121.

⁸⁴⁰ The skilled person responsible for evaluating the inventive step might not be the same as the one determining sufficiency of disclosure, even when dealing with the same invention. (Paul England, *A Practitioner’s Guide to European Patent Law: For National Practice and the Unified Patent Court* (Hart 2019) 10; see also: Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 70; Paolo Guarda and Laura Trevisanello, ‘Robots as artists, robots as inventors, is the intellectual property rights world ready?’ (2021) 43(11) *European Intellectual Property Review* 744.

Firstly, the relevant technical field must be identified.⁸⁴¹ For an invention to qualify as having an inventive step, it must not be something that a skilled person could have foreseen based on existing knowledge and technology. In other words, the invention should be unexpected according to the collective experience in the field and not merely an obvious extension of what was already known.

This relevant technical field, representing the branch in which the inventor operates and where the invention is realised and utilised, serves as the foundation for defining the average technician. Whilst this identification is often straightforward, it gets increasingly complicated when more than one field could be fitting.⁸⁴² The state of the art pertinent to the evaluation of non-obviousness is reconstructed based on the entirety of accessible knowledge and must be crystallized at the time of filing the application.⁸⁴³

It is vital to identify the relevant field of technology to determine the degree of expertise and knowledge required of the person skilled in the art. This ensures that the evaluation aligns with the standards of the specific field. Depending on the subject matter of the invention and the technological field, the pertinent branch of technology is determined case by case, considering whether it may be wider or narrower than the field of application. For reference, in decisions dating back to the 1980s, the BoA characterised the person skilled in the art within the field of biotechnology as a scientist operating in laboratories undergoing the transition from molecular genetics to genetic engineering. This hypothetical individual was situated between the extremes of a Nobel laureate and a laboratory technician in terms of expertise.⁸⁴⁴

Secondly, the construction of the expert's model involves defining their knowledge, skills, and available tools. This model establishes the parameters against which evidence or non-evidence is assessed to derive findings from the state of the art.⁸⁴⁵ The knowledge of the person skilled in the art tends not to coincide with the knowledge concretely used for the realisation of the invention, as it is not possible to know what specific "knowledge" the operator has drawn on in the inventive process. It is also possible that the operator has drawn on knowledge from distant sectors or knowledge that is not strictly technical.⁸⁴⁶ Still, this skilled person serves as a hypothetical representative of the target audience within the relevant field, functioning as an interpretative instrument that helps to construct an objective judgment of the technical

⁸⁴¹ Kaisa Suominen et al., *Drafting Patents for Europe* (2nd edn, CIPA 2021) 184.

⁸⁴² When determining the skilled person for assessing the inventive step, the EPO takes into account the technical problem to be solved. If addressing this problem necessitates that the skilled person acquire expertise from a different technical field, the skilled person is then considered a specialist in that secondary field (Colin Birss et al., *Terrell on the Law of Patents* (19th edn, Sweet & Maxwell 2020) § 8-32; EPO, T 26/98, 30 April 2002 (*Iontophoretic delivery device/ALZA CORPORATION*) § 6.3; Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 175).

⁸⁴³ Tribunale di Milano, 5 ottobre 1978, in *Giurisprudenza Annuale di Diritto Industriale* (1978) 583; Tribunale di Bari, 10 giugno 1974, *ivi*, (1974) 814; Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè 2021) 410; Vincenzo Di Cataldo, 'I brevetti per invenzione e per modello di utilità. I disegni e modelli' in P Schlesinger (ed), *Commentario al codice civile* (Giuffrè 2012) 107.

⁸⁴⁴ EPO, Case Law of the BoA 2022, I-D, 8.1.3; see also: Timo Minssen, 'Meanwhile on the Other Side of the Pond: Why Biopharmaceutical Inventions That Were Obvious to Try Still Might Be Non-Obvious - Part I' (2010) 9(1) *Chicago-Kent Journal of Intellectual Property* 84.

⁸⁴⁵ Vincenzo Di Cataldo, *L'originalità dell'invenzione* (Giuffrè 1983) 61 et seq.

⁸⁴⁶ *Ibid.*, 74-75; Andrea Ottolia, 'Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30', in L C Ubertaini (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (7th edn Wolters Kluwer 2019).

advancements associated with the invention.⁸⁴⁷ It is a legal construct that is impartial to the subjective conditions influencing the assessment of an inventive step and is designed to embody specific legal standards, and its configuration is contingent on the purpose it serves at any given time.⁸⁴⁸ Despite adjustments made for diverse assessments, the person skilled in the art remains a consistent entity shaped to meet the requirements of various legal contexts.⁸⁴⁹ Technological advancements, especially in AI, can introduce significant variations in the distances between different branches of technology. This complexity makes it challenging to reconstruct the state of the relevant technique and the knowledge attributed to the expert, particularly in relation to neighbouring branches.⁸⁵⁰

Thirdly, evidence or non-evidence must be evaluated to derive findings from the state of the art pertinent to the expert of the branch. The criterion for establishing an inventive step requires verifying whether the expert in the field would have considered the invention obvious or common knowledge according to a judgment made *ex ante*, at the time of the invention's priority date, and avoiding the influence of hindsight.⁸⁵¹ Evidence of an inventive step exists when the state of the art contains an implicit suggestion or incentive to adopt the solution or when there are realistic prospects of achieving a useful result. Specific challenges arise in emerging fields of technology, limited to avant-garde researchers, where attributing specific notions to the skilled person and drawing knowledge from other fields can pose difficulties.⁸⁵² The identification of the relevant field is foundational for subsequent phases of judgment on inventive activity. In the context of new technology fields, initially, notions attributed to the expert pertain to neighbouring fields based on the concept of affinity. As research progresses into concrete industrial operations, the skilled person's figure is defined based on the experience acquired by operators.⁸⁵³

4. Initial Considerations for AI-Related Inventions

Considering the EPO Guidelines, the integration of AI in the innovation process prompts several important questions. Specifically, it invites scrutiny of how the “relevant field of technology” and the person having ordinary skills in the art's identity, average knowledge, ability and tools at disposal (further debated in Section D.II) should be understood in this

⁸⁴⁷ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.; Johanna Gibson, ‘Artificial Intelligence and Patents: DABUS and Methods for Attracting Enhanced Attention to Inventors’ 11(4) *Queen Mary Journal of Intellectual Property* 401 et seq.

⁸⁴⁸ Andrea Ottolia, ‘Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30’, in L C Ubertazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (7th edn Wolters Kluwer 2019) 380.

⁸⁴⁹ Mark A Lemley and Dan L Burk, ‘Policy Levers in Patent Law’, 89 *Virginia Law Review* (2003) 1189 (stating that the person skilled in the art for assessing obviousness may differ from the one considered for evaluating enablement, written description, definiteness, or equivalence).

⁸⁵⁰ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 96.

⁸⁵¹ Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 124 et seq.

⁸⁵² Ibid.

⁸⁵³ Ibid, 99.

context. A further question concerns the scope of the data accessible to AI in establishing “common general knowledge” as of the relevant filing date (further debated in Section D.II).

One of the main problems of AI-related inventions is the identification of the relevant field the person skilled in the art must be an average technician of.⁸⁵⁴

A first option would be to consider AI a branch of computer science and, therefore, a distinct technological field on its own, which increasingly leads to multidisciplinary nature of research and innovation. In patent law, this leads to a person skilled in the art with knowledge in several fields and even multiple experts, rather than a single individual knowledgeable in one field. Therefore, the relevant field(s) in AI-related inventions would likely need to be AI and an additional field depending on the invention.

A second option would be to recognize that certain technical problems go beyond one field.⁸⁵⁵ Determining whether AI is regularly used within the relevant field is essential. This helps to establish the baseline of AI integration in the innovation process. The initial task would involve determining whether AI is consistently used within the relevant field and whether practitioners have the capacity to leverage AI.⁸⁵⁶ For instance, in the pharmaceutical sector, the employment of AI is prevalent in screening procedures.⁸⁵⁷ However, scenarios are conceivable where AI use might already represent an exceptional achievement within research fields, exceeding the capabilities of the average specialist.⁸⁵⁸

There is, moreover, the question of how AI systems access “general technical” versus “remote technical” fields when limited to specific datasets. Human examiners typically constrain prior art searches by classification schemes such as the International Patent Classification or the Cooperative Patent Classification, reflecting the assumption that the skilled person operates within a defined technical domain. In contrast, unless explicitly programmed otherwise, AI systems may have unrestricted access across technical fields, which could influence the determination of remoteness between fields and prompt a re-examination of EPO case law distinguishing “neighbouring fields” in relation to inventive step. Still, whether AI’s access to remote fields is permissible or relevant depends on programming choices and the specifics of

⁸⁵⁴ Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 130, who add as an example the hypothesis of machines in unrelated fields, however, presenting operating problems that are independent of the specific function performed. In this sense also the EPO Guidelines 2025, Part C-IV, 11.3, according to which the expert in the field must be expected to draw suggestions in neighbouring sectors and general technical knowledge, and also in distant sectors, if is prompted to do so, reiterating the need not to resort to abstract assessments in this in this regard.

⁸⁵⁵ This also applies on the basis of American case-law which, for the purposes of judging inventive step, takes into account, among other variables, the “sophistication of technology” at the disposal of the expert in the field (again, not the person who actually carried out the invention, who may have lower or higher than average skills and knowledge) (Catherine Seville, *EU Intellectual Property Law and Policy* (2nd edn, Edward Elgar 2018) 147; Peter S Menell et al., *Patent Case Management Judicial Guide* (Berkeley 2009) 11-47, where it is explained that “in determining the level of ordinary skill in the art, courts look to the inventor’s educational level, the nature of the field’s typical problems, the skill required to grapple with the prior solutions to the field’s problems, the pace of innovation in the field, the sophistication of technology and the educational level of people working in the field” and reference is made to decision *Environmental Designs, Ltd v Union Oil Co* 713 F2d 693, 696 (Fed Cir 1983).

⁸⁵⁶ Internet Association et al., ‘Comments on Patenting Artificial Intelligence Inventions’ (USPTO, 8 November 2019) 16, https://www.uspto.gov/sites/default/files/documents/Internet%20Association_RFC-84-FR-44889.pdf.

⁸⁵⁷ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 30.

⁸⁵⁸ Rainer Schulte et al., *Patentgesetz mit EPÜ*, (11th edn, Carl Heymanns, Cologne 2022) § 4 para 46.

the machine learning model employed, while the relevance of such access must be assessed by the human examiner during prosecution.

From one perspective, by incorporating AI as a tool used by the average technician, the model becomes more closely aligned with reality and supports the presumption of universal knowledge in the relevant field, rather than undermining it. Incorporating AI into the average technician's toolkit could potentially address the issue of diminishing expertise as one moves away from the relevant field.⁸⁵⁹ This would help to reduce the abstractness that characterises the conventional approach where an average technician in a particular field is expected to have diminishing knowledge as they move further away from their area of expertise.

From another perspective, AI could potentially make the idea obsolete, since what makes AI so special and potentially the contributor to life changing inventions, is its capability to collect and connect data from different fields.⁸⁶⁰ Given AI's ability to combine different fields of research beyond the limitations of human knowledge, this would result in a higher standard for the cumulative amount of combinatorial inventions.⁸⁶¹ The inventor's actual capability and knowledge would surpass what is attributed to an average technician in the field through *fictio iuris*.

It follows that if AI is deemed relevant to the invention, the capabilities of the average technician can be assessed differently in constructing the person skilled in the art. This distinction can be made between a technician who is a mere "user" of AI technologies, and one who is capable of creating new AI algorithms or perfecting existing ones, leading to the presumption of an ad hoc development of technologies in the inventive process that may not be accessible to every technician in the field. However, this solution is not without criticism, as the relevant sector of technology should pertain to the invention itself, not just the inventive process. Nevertheless, the case law of the BoA appears to allow for the assessment of this circumstance.⁸⁶²

Still, while AI applications have virtually infinite memory capacity, depending only on the availability of computational and data storage resources, the existing knowledge may be

⁸⁵⁹ Cesare Galli and Mariangela Bogni, 'Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach' (2020) 2 *Il Diritto industriale* 130; Ana Ramalho, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 24 et seq. ("clear common guidelines on the notion of analogous, neighbouring or adjacent art" in the different legislations as "a way to counteract the effects of a potential 'race to patent' derived from the easiness to invent in the context of AI", as "Since non analogous art cannot be used when judging whether the invention is obvious or nonobvious, the scope of 'analogous/neighbouring/adjacent art' should be broadened in Examination Guidelines").

⁸⁶⁰ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 37 (stating that "machine augmentation suggests that the analogous arts test should be modified or abolished once inventive machines are common, and that there should be no difference in prior art for purposes of novelty and obviousness"). The expansion of what should be considered analogous art has been discussed in American case law in *Innovative Scuba Concepts, Inc v Feder Indus, Inc* 819 F Supp 1487, 1503 (D Colo 1993); *George J Meyer Mfg Co v San Marino Elec Corp* 422 F2d 1285, 1288 (9th Cir 1970); see also: Daniele Cerulla, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) 118.

⁸⁶¹ Hyejin Youn et al., 'Invention as a Combinatorial Process: Evidence from US Patents' (2015) 12(106) *Journal of the Royal Society Interface*.

⁸⁶² Daniele Cerulla, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) 122.

incomplete. In theory, it is possible to consider a solution that incorporates all available knowledge of every field, but in practice, it may not be feasible due to the limitations of data collection and processing.

5. Preliminary Remarks

The concept of the person skilled in the art is central in the assessment of inventive step. This hypothetical figure represents an objective standard—a professional with average knowledge and abilities in the relevant technical field—used to determine whether an invention is obvious in view of the prior art. The assessment involves three key elements: identifying the person skilled in the art and the common general knowledge, comparing the invention with the prior art, and evaluating whether the differences would have been obvious to the skilled person.

The standard focuses on what a skilled person could achieve, independent of the inventor’s personal process or insight. The person skilled in the art is not inventive, but capable of logical reasoning, experimentation, and consulting known sources or experts. In interdisciplinary inventions, the skilled person may comprise a team of experts. While the state of the art is assessed globally, the person skilled in the art is generally rooted in the relevant geographical and technical context.

In the context of AI-related inventions, challenges arise in defining the appropriate field(s) of expertise and in determining how AI tools influence the scope of general knowledge. AI may alter the conventional understanding of the person skilled in the art by enabling access across technical domains and combining knowledge beyond human capability. The evolving role of AI prompts reconsideration of the skilled person’s identity and the boundaries of inventive step in technologically complex or multidisciplinary cases.

II. The Means and Tools at Disposal

1. Introductory Remarks

The person skilled in the art possesses the capacity and has at disposal “means and capacity for routine work and experimentation which are normal for the field of technology in question”, for example setting parameters, pre-processing data, choosing training and validation sets.⁸⁶³ The means for routine work and experimentation are therefore the ones considered “standard” in the relevant technical field.⁸⁶⁴ This includes common general knowledge, relevant literature, patent applications, and other accessible materials. The means at disposal include not only conventional information sources but also tools and methods widely applied in the field. The skilled person carries out customary experiments, utilising ordinary means available in the sector, such as intellectual skills, techniques, equipment, and tools typical for those active in

⁸⁶³ EPO Guidelines 2025, Part G-VII, 3.

⁸⁶⁴ EPO Guidelines 2025, Part G-VII; Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 4 et seq.

the specific field.⁸⁶⁵ In T 676/94 the BoA established that “the skilled person addressing the problem of bringing together certain starting materials, the conclusions of research on these materials carried out by only a very few manufacturers form part of the relevant general technical knowledge, even if the studies in question have only been published in technical journals”.⁸⁶⁶ Therefore, in special cases, articles in technical journals can be representative of common general knowledge.⁸⁶⁷

The identification of knowledge for the purpose of patentability assessment is based on a *fictio iuris* that assumes the state of the art has no territorial limits. Conversely, the identification of the capabilities of a skilled technician in a particular field requires an empirical investigation of the actual capabilities that operators in that field possess on average, which may vary depending on the geographic context.⁸⁶⁸ There is a problematic assumption that the average technician lacks creative talents, which is often used as a balance to the *fictio iuris* that assumes the technician is omniscient.⁸⁶⁹ However, this view is not supported by the law, which only provides for a *fictio iuris* in the first sense. In reality, the technician’s creative capacity must be ascertained based on actual capacities that can be deduced from operators in the relevant fields.⁸⁷⁰ The crowdedness of a technological field should not be a decisive factor in determining the judgment of the inventive activity. Instead, considerations should focus on the time, cost, and certainty of the research required, compared to what an average technician in the same field would normally face.

This can be applied *mutas mutanda* also to the tools used. In patent law, the rules for determining the common general knowledge of the skilled person can be used as a guideline to decide if a tool can be considered “standard” in a certain field of research. It is therefore a “fictive” concept, as the person skilled in the art itself, deducible from the common general knowledge. In T 1464/05 for example, the BoA considered the features made available to the public by obvious prior use to be the closest state of the art.⁸⁷¹ The discussion on what can be considered a “standard” tool was also touched upon in the cases where the BoA discussed the relevance for everyday items from a different technical field. In this case, the question that arise was if the skilled person would immediately arrive at the claimed invention, if the invention was made with the use of a general “everyday item”.⁸⁷² Generally speaking, the average skilled

⁸⁶⁵ According to BoA case law, “nothing more can be expected [from the PSITA] than the carrying out of experimental work by routine means within the framework of the normal practice of filling gaps in knowledge by the application of existing knowledge” (EPO, Case Law of the BoA 2022, I-D, 8.1.3).

⁸⁶⁶ EPO Guidelines 2025, Part G-VII, 3.1; EPO, T 676/94, 6 February 1996 (*Radial tyre/SUMITOMO*).

⁸⁶⁷ EPO, T 595/90, 24 May 1993 (*Grain oriented silicon sheet*).

⁸⁶⁸ There are two contrasting views on the scope of such an investigation. Some experts believe that the relevant territory for assessing the technician’s capabilities should be worldwide, similar to the search for prior art in novelty assessment. Others argue that only the territory of the state where the patent is sought should be considered, based on both legal and practical reasons. (Vincenzo Di Cataldo, *L’originalità dell’invenzione* (Giuffrè 1983) 73).

⁸⁶⁹ James B Gambrell and John H Dodge, ‘Ordinary Skill in the Art - An Enemy of the Inventor or a Friend of the People?’ in John F Witherspoon (ed), *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs 1979) 5:325 et seq.; Ettore Luzzatto, *Teoria e tecnica dei brevetti d’invenzione* (Istituto Editoriale Cisalpino 1960) 115.

⁸⁷⁰ Vincenzo Di Cataldo, *L’originalità dell’invenzione* (Giuffrè 1983) 74.

⁸⁷¹ EPO, Case Law of the BoA 2022, I-D, 8.1.1; EPO, T 1464/05, 14 May 2009 (*Hydrogen-absorbing composition/PRYSMIAN*).

⁸⁷² In EPO, T 1043/98, 11 May 2000, the patent concerned an inflatable gasbag for a vehicle restraint system, one part being club-shaped and the other generally butterfly-shaped. According to the appellant, the skilled person

person referred to in Article 56 EPC is “aware of the totality of the state of the art” in the relevant technical field and in particular of all that has been made available to the public within the meaning of Article 54(2) EPC.

2. AI as Part of the Toolkit of the Skilled Person

As mentioned in the previous chapters, the patent system is based on a *quid-pro-quo*,⁸⁷³ a social contract.⁸⁷⁴ Exclusive rights are granted for the invention, that is made public, but only if said invention adds something new and inventive to the existing technical knowledge and therefore contributes to the existing state of the art.⁸⁷⁵ From a pure social contract perspective and traditional rationale of the inventive step requirement, it is irrelevant whether the invention was made using tools, including AI, or that AI has functioned as the inventor.⁸⁷⁶ The assessment of the inventive step is unique to each situation and depends on the specific facts of the case. The skilled person’s definition, which is important to this assessment, is also specific to each case. The use of AI as a standard tool in a particular field is determined by the current state of technology, which is determined by prior art.⁸⁷⁷

The integration of AI in patent examination raises important questions about the perspective from which the inventive step should be assessed, considering the varying adoption rates of AI in different industries.⁸⁷⁸ It is argued that AI tools, like previous major cross-sector technological advancements as computer programs in the 1970s and potentially quantum computing in the future, could influence every stage and aspect of the inventive step analysis.⁸⁷⁹ This impact extends to the identity, knowledge, abilities of the notional skilled person, and what would be considered obvious to them.⁸⁸⁰ Questioning whether the skilled person is knowledgeable in AI systems (their knowledge) or if the skilled team includes an AI expert (their identity) are essentially two sides of the same coin.⁸⁸¹ The characteristics of the skilled person and what would be obvious to them are also inherently interdependent questions.

would immediately arrive at the claimed gasbag from his knowledge of tennis-ball or baseball construction. This raised the issue of the application of features or solutions drawn from another technical field, but which could be considered “everyday items”.

⁸⁷³ Chris Dent, ‘An exploration of the principles, precepts and purposes that provide structure to the patent system’ (2008) 4 *Intellectual Property Quarterly* 462 et seq.

⁸⁷⁴ David Vaver, ‘Intellectual property: still a “bargain”?’ (2012) 34(9) *E.I.P.R.* 579; Adriano Vanzetti, Vincenzo Di Cataldo and Marco S Spolidoro, *Manuale di Diritto Industriale* (9th edn, Giuffrè Editore 2021) 377.

⁸⁷⁵ EPO, ‘Caselaw of the BoA, art 56 EPC Introduction’ <https://www.epo.org/en/law-and-practice/boards-of-appeal/communications/selected-depth-reviews-case-law-boards-appeal-10th>.

⁸⁷⁶ Anna C Comer, ‘AI: Artificial inventor or the real deal?’ (2021) 22(3) *North Carolina Journal of Law & Technology* 479-480.

⁸⁷⁷ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 31.

⁸⁷⁸ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 112 et seq.

⁸⁷⁹ Michael Brooks, ‘Quantum computers: what are they good for?’ (2023) 617 *Nature* 1 et seq.

⁸⁸⁰ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 224.

⁸⁸¹ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866.

Patent law assumes that the skilled person is aware of all publicly available information, including tools and technologies, that form part of the state of the art. While it is unrealistic to assume that every skilled person in the field would have known every single feature made available to the public by prior use, the concept of a skilled person under Article 56 EPC ensures that any obvious development or application of these publicly known features by a skilled person who is aware of them is treated as obvious under Article 56 EPC. This assessment is made regardless of whether all members of the interested public are actually aware of these features, focusing instead on what would be obvious to a hypothetical skilled person with access to the relevant prior art.⁸⁸²

Assessing from the perspective of a person skilled in the art without AI might make it easier for those using AI early to secure patents, potentially fostering innovation in AI-related fields. This aligns with the inducement theory, which suggests that patents can encourage innovation. If AI is not yet widely used, the inventive step examination should assume a person skilled in the art without AI access. This approach suggests that incorporating AI into the assessment could unfairly raise the bar for inventors who do not use AI, making it harder for them to obtain patents.

Still, if AI is considered a common tool, it would be rational that a patent can only be granted if the invention would not have been obvious to a skilled person who used AI.⁸⁸³ Therefore, since the skilled person is a dynamic model that evolves with technical progress, AI should be included once it becomes a routine tool for standard work and experimentation in the relevant field.⁸⁸⁴ As AI becomes an increasingly important tool in an increasing number of fields, it may be considered part of the standard toolkit for the skilled person in those fields. If the use of AI is a normal means of experimentation in the relevant field, the person skilled in the art must use similar technologies. This implies that a patent may be granted if the invention is not obvious to a person skilled in the art using AI, regardless of if the invention was made with or without the use of AI.⁸⁸⁵ Also, despite AI's current limited use, its rapid growth justifies expecting a

⁸⁸² In reference to the different means by which the state of the art can be made available to the public, these are to be considered of equal importance (EPO, T 1464/05, 14 May 2009 (*Hydrogen-absorbing composition/Prysmian*)).

⁸⁸³ Daria Kim et al., 'Ten Assumptions About Artificial Intelligence That Can Mislead Patent Law Analysis' (2021 MPI Research Paper No. 21-18, 12 <https://ssrn.com/abstract=3910332>; Anne-Marie Verschuur et al., 'Summary Report, 2021 – Study Question Inventiveness and sufficiency of disclosure in AI inventions' (AIPPI, 20 July 2021) 33; Peter Blok, 'The inventor's new tool: artificial intelligence - how does it fit in the European patent system?' (2017) 39(2) *European Intellectual Property Review* 71; Olga Gurgula, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 17.

⁸⁸⁴ Daria Kim et al., 'Ten Assumptions About Artificial Intelligence That Can Mislead Patent Law Analysis' (2021 MPI Research Paper No. 21-18, 12 <https://ssrn.com/abstract=3910332>; Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 27; EPO, 'Comments by the European Patent Office, WIPO Conversation on Intellectual Property (IP) Artificial Intelligence (AI), Second Session July 7 to 9, 2020, Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence' 8 (WIPO/IP/AI/2/GE/20/1 REV), stating that "if AI is used in the relevant field of technology, it will be used by the skilled person and their skill will raise accordingly".

⁸⁸⁵ Ana Ramalho, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 25; Peter Blok, 'The inventor's new tool: artificial intelligence - how does it fit in the European patent system?' (2017) 39(2) *European Intellectual Property Review* 71-72; William Samore, 'Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?' in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial*

skilled person to incorporate AI into their skill set. Although this approach might disadvantage non-AI users, the market's natural incentives to adopt AI could mitigate such concerns, driving AI adoption.

Patent office might have to ascertain whether the skilled person's skillset comprises AI expertise. This determination would hinge on the range of skills necessary to address the problem that the invention aims to solve. For instance, if Watson Health or similar AI capabilities have become routine in the relevant field and are employed to analyse patient medical information or design drugs, the research team in question should include AI tools and expertise.⁸⁸⁶ In the specific case, the decision on which AI technology should be used lies with the patent examiner, who must determine what a person skilled in the art would have chosen, or the examiner must consider whether the assessment should be conducted based on the machine's capabilities alone or if they should ask the identified AI to perform certain operations to compare its outputs. The first option seems preferable since the second option poses a practical problem on how such a "simulation" should be carried out in practice. The evaluation of the inventive step must be conducted objectively and in abstract.⁸⁸⁷ Therefore, a possible concrete test of the machine could, at most, be useful in the context of a technical consultation as an indication of non-obviousness, but it cannot exhaust the evaluation of the inventive step on its own.

Even prior to examining the inventive step, it may be useful to consider the human operator's preference for a specific AI technology in conducting research. In cases where achieving the same result is possible through the use of different technologies, the selection of a specific AI solution may be deemed obvious. However, if the state of the art has not established a clear preference for a certain AI application or combination of technologies, and the order in which they should be used, then the search of the inventive step may not be obvious. In such cases, the person skilled in the art must select the appropriate AI technology for the specific task at hand.

3. Considerations for Establishing if AI is a "Standard" Tool

Considerations for establishing if AI is a "standard" tool in a specific sector should include various reasonings.

Firstly, the current state of the industry is relevant since the degree of AI adoption and integration within the sector is critical. It is more likely that AI will be regarded as a "standard" tool if it is frequently used and acknowledged as a regular tool for assessing the inventive step.

Intelligence (Edward Elgar 2018) 133 et seq. (calling it a "widespread use test" that in his opinion does not concern the actual use of AI but only the diffusion in the field of the invention).

⁸⁸⁶ Noam Shemtov and Garry Gabison, 'The Inventive Step Requirement and the Rise of the AI Machines' (2022) *Queen Mary Law Research Paper No. 375/2022* 10.

⁸⁸⁷ Andreas Rahmatian, 'A Fundamental Critique of the Law-and-Economics Analysis of Intellectual Property Rights' (2013) 17 *Marquette Intellectual Property Law Review* 192 et seq.; Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law' (2018) 39 *Cardozo Law Review* 2232 et seq.

It might not be regarded as a standard tool if its application is restricted or not yet widespread. Computer programmes are already commonly considered “means” and “capacity” that facilitate the work of any researcher, and AI could be the next logical step of means to do research and be considered a common tool.⁸⁸⁸ For example, the SARS-CoV-2 pandemic has accelerated the use of AI in the pharmaceutical sector, following in the trend of the past years of making more and more AI tools available.⁸⁸⁹ Given the rapid advances in AI and the increasing demand for innovative solutions, it is likely that AI will become an increasingly important tool for invention in this field in the coming years. The pace of adoption will depend on a variety of factors, including the cost and availability of AI tools, the willingness of researchers to learn and use them, and the level of support and investment from governments and private industry.

Secondly, technological improvements, including the capabilities, precision, and dependability of AI are important elements. It may be more likely that AI will be regarded as a typical tool for assessing the inventive step if it has developed to the point where it can offer useful insights, predictions, or solutions that would not be obvious to a person skilled in the art.⁸⁹⁰ The reliability and disclosure of AI are also significant factors. Even if assessing the inventive step from a skilled person with AI suggests that AI facilitates invention, the low reliability of AI could counteract this effect. A skilled person may not trust AI predictions, leading to a lack of confidence in achieving success, which would impact the inventive step assessment. However, given the rapid advancements in AI capabilities, it is only a matter of time before AI produces more reliable results. Therefore, the current low reliability of AI should not be used as an excuse to sidestep discussions on AI’s impact on the inventive step. Consequently, current concerns about AI reliability may not prevent the eventual need to consider how a skilled person with AI influences the inventive step.⁸⁹¹

Thirdly, legal precedents as previous rulings and precedents concerning the use of AI in assessing the inventive step may have an impact on how widely accepted AI is as a tool. It may help to consider AI as such if there are documented instances when it has been acknowledged and accepted as a standard tool in a specific sector. Lastly, the specific context of the invention should be taken into consideration and the judgement will be influenced by elements like the invention’s complexity, how much AI is used, and how much innovation went into using AI.

⁸⁸⁸ See for example: Brenda M Simon, ‘The Implications of Technological Advancement for Obviousness’ (2013) 19 *Michigan Telecommunications and Technology Law Review* 331 et seq.; Rebecca S Eisenberg, ‘Obvious to Whom? Evaluating Inventions from the Perspective of PHOSITA’ (2004) 19(3) *Berkeley Technology Law Journal* 885.

⁸⁸⁹ Arash Keshavarzi Arshadi et al., ‘Artificial Intelligence for COVID-19 Drug Discovery and Vaccine Development’ (2020) 3 *Frontiers in Artificial Intelligence* 65; Debleena Paul et al., ‘Artificial Intelligence in Drug Discovery and Development’ (2021) 26(1) *Drug Discovery Today* 84; Salman Akhtar et al., ‘Machine Learning Approaches to Rational Drug Design’ in Singh (ed), *Computer-Aided Drug Design* (Springer Nature, Singapore 2020) 295; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 51.

⁸⁹⁰ Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 15; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 50 et seq.

⁸⁹¹ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era - A Japanese Perspective’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 112 et seq.

Ultimately, the level of expertise of a skilled person should guide the inventive step assessment, rather than the actions of applicants. As long as a skilled person is expected to incorporate AI into their skill set, the examination of the inventive step should be based on a person skilled in the art with AI expertise. The inventive step remains rooted in the capabilities of the hypothetical person possessing ordinary skills in the art. It is essential to remember that the inventive step is a strictly objective requirement. There should be no prior distinction between “normal” inventions and AI-related inventions; both should be evaluated against the properly construed skilled person.⁸⁹²

4. Defining the AI Tool

There are questions about whether AI can be considered a mean at disposal of the skilled person and if so, what constitutes a “standard” AI tool, especially in machine learning where the choice of algorithms varies widely. Assessing what constitutes the capabilities of “normal” AI tools is complex.

The use of AI technologies in inventive procedures also raises questions about how to identify which AI technology(s) should be available to the person skilled in the art to conduct the inventive step examination.⁸⁹³

Starting with the concept of tools, as discussed in a) AI-Assisted Inventions, these usually start by being “special”, meaning that there are only one or a few available because they are a complex prototype not yet intended and ready for mass production. A tool becomes “standard/normal” in the moment it stops being a “special” tool and becomes a die, jig, fixture, mold, pattern or gauge. Therefore, as tools become more sophisticated, they evolve from complex prototypes into standardized products, readily available to the public. A recent example is the computer: when it was first invented it was a “special” machine, whilst now it is a “standard/normal” tool produced and used by many. Therefore, a tool becomes “standard/normal” when it has a standardised production, is commercialised, and can be purchased. In relation to AI, online translation software for example started from being available to only a few companies, being pricey and unavailable to the public to now being often free of charge, commercialised and easily available to everyone - therefore a “standardised” tool.

Moreover, it is essential to differentiate between “bespoke”, “off-the-shelf”, and “commercial” AI tools. These terms are often used loosely. A “bespoke” model is one that the skilled person must build from scratch. An “off-the-shelf” model is available in online but requires customisation. A “commercial” model/application is a finished product (either under license or open source) used “as is”. The amount and complexity of evidence required to demonstrate that any of these tools is “normal” in a technical field inversely correlates with their level of

⁸⁹² Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) *Il Diritto industriale* 131.

⁸⁹³ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 6, who suggests for the American legal system to include “technologies used by active workers” as an assessment parameter.

customisation, with a “commercial” model being the simplest to qualify.⁸⁹⁴ This requires a thorough investigation into how widespread AI is in the relevant field, which specific applications are available, and whether it is standard equipment in the field. An examination that looks at the entire field of the invention and the technologies used in that field would need to be conducted. Specifically, any task that a skilled person can perform using only widely available software, LLMs, machine learning tools, or AI (for example “ChatGPT -4o” starting May 2024) without any inventive effort in configuring the system for a specific purpose, will be considered obvious under Article 56 EPC.

When it is generally accepted that a “commercial” tool (for example, ChatGPT, Google’s Gemini) is not only widely available but also commonly accepted and used in the technical field, as evidenced by publications and studies, it becomes a strong candidate to be considered a “normal tool” in that field.⁸⁹⁵ The more customized the allegedly “normal” model, the more evidence is needed to demonstrate what specifically is “normal” in the field. For instance, one might need to show that a skilled person would typically choose a specific type of machine learning model/architecture from a library like GitHub, just as a skilled person would consult a database considered part of common general knowledge and would know how to train and tweak it to solve the objective technical problem at hand. Additionally, there might be field- or problem-specific preferences. For example, evolutionary algorithms have shown promising results in antenna and circuit design.⁸⁹⁶ In such fields, it can be argued that using evolutionary algorithms for antenna design is part of the common general knowledge. Conversely, machine learning has proven effective for tasks requiring pattern identification, such as drug repurposing and target validation in pharmaceutical research. Given the broad categories of machine learning and evolutionary algorithms, if certain research methods within these categories become established and widely accepted, they would become part of the common general knowledge.

Second, even if the knowledge of and use of a specific type of AI tool is considered part of common general knowledge, this alone may not suffice for an adequate obviousness assessment (unless it is a “commercial” tool). Hyperparameters, such as the architecture of an artificial neural network in terms of the number of nodes and layers, fitness/objective functions implemented, and learning rate, are also crucial.⁸⁹⁷

Third, in evaluating the characteristics of “normal” AI tools, interpreters must be especially cautious of hindsight bias, where an idea that was not obvious at the time of invention *ex ante*

⁸⁹⁴ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 234.

⁸⁹⁵ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 868 et seq.

⁸⁹⁶ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 235.

⁸⁹⁷ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 96 et seq.; Daria Kim et al., ‘Clarifying Assumptions About Artificial Intelligence Before Revolutionising Patent Law’ (2022) *GRUR International* 317, where that authors elaborate that (a) fitness functions in genetic programming (GP) or EAs are highly application-specific and typically require significant expertise to design; (b) while common functions exist for artificial neural networks, human input is critical in deciding hyperparameters; and (c) existing objective functions might need adjustment for specific problems.

may appear obvious *ex post*.⁸⁹⁸ The problem-and-solution approach partially addresses this by reconstructing the steps taken by the inventor without considering the subjective conditions in which the invention was made.⁸⁹⁹ This reduces the risk of arbitrary analysis.⁹⁰⁰ Nevertheless, there are criticisms that the way the objective technical problem is posed and the difficulty of modelling the expert may lead to an *ex post* evaluation.⁹⁰¹ AI systems are continually improving, but any enhancements made after the priority/application date must be disregarded in the inventive step assessment.⁹⁰² This can be particularly challenging when dealing with “commercial” AI tools, as the capabilities of tools like ChatGPT can significantly change within a few months. Thus, the skilled person’s abilities will expand with the development of available tools.⁹⁰³ While this sounds reasonable, taking the example of ChatGPT, the LLMs evolved from “Legacy ChatGPT 3.5” (November 2022) to “ChatGPT 3.5 Default” (early 2023), “ChatGPT-4” (March 2023), and “ChatGPT-4o” (May 2024). Each version improving the previous one.

The assessment of the inventive step must be based on the AI tools and versions available at the priority date of the invention. The person skilled in the art should therefore have at their disposal the AI version that was accessible at the date of priority, not future versions that were not yet developed or released. However, even with this approach, the absence of a disclosure obligation, including any licensing contracts or technology transfer agreements between innovation companies and AI system producers, can make it challenging to reconstruct the technical conditions.⁹⁰⁴

For this reason, several scholars have suggested the introduction of a disclosure requirement (later discussed more in detail in Section F.I.2) in the patent application of the possible use of AI.⁹⁰⁵ This would enable an assessment of the inventive step that considers the actual technologies used in the invention process, which may vary depending on what the applicant declares. It would help to create a more accurate picture of the technologies employed in a particular field, facilitating better modelling in future assessments by an expert in the field that

⁸⁹⁸ In doctrine, the problem has frequently arisen, and reference is often made to the anecdote of *Columbus’* egg (V van Benthem and Wallace, ‘The Problem of Assessing Inventive Step’ (1978) *IIC* 301).

⁸⁹⁹ The essence of this approach is that it is not merely enough to demonstrate that a skilled person could have reached the specific solution by combining known elements; rather, the solution is deemed obvious if an average practitioner would naturally combine those elements to achieve the claimed invention. The focus is on whether the combination would be an expected and logical step for someone with ordinary skills in the field, rather than on the mere possibility of arriving at the solution (G Knesch, ‘Assessing Inventive Steps in Examination and Opposition Proceedings in the EPO’ (1994) *epi (European Patent Institute) Information* 95 et seq.).

⁹⁰⁰ Cesare Galli, ‘Per un Approccio Realistico al Diritto dei Brevetti’ (2010) *Il Diritto Industriale* 136.

⁹⁰¹ Lionel Bently et al., *Intellectual Property Law* (5th edn, OUP 2018) 471; Jeanne M Claydon, ‘The Question of Obviousness in the Windsurfer Decision’ (1985) *European Intellectual Property Review* 218.

⁹⁰² Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 869 et seq.; Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 338 et seq.

⁹⁰³ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 2-25 passim; Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.

⁹⁰⁴ Rosario Girasa, *Artificial Intelligence as a Disruptive Technology* (Palgrave MacMillan 2020) 228 et seq.

⁹⁰⁵ Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 333; Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 26 et seq.; Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 35.

reflects reality.⁹⁰⁶ The proposal to model the standard more appropriately has received both praise and criticism. One of the criticisms is that it risks placing too much emphasis on the process of invention rather than the technical merits of the invention itself. The requirement that the inventor explains how they get to the inventive result may lead to excessive focus on the process and may make it difficult to assess the technical merits of the invention.⁹⁰⁷ In addition, it can be difficult to determine the use of an invention without an explicit statement, as this circumstance cannot be easily deduced from an analysis of the invention as such. The difficulty in enforcing the disclosure mechanism may disadvantage efficient companies investing in state-of-the-art research tools, as they may be less likely to use explicit claims in their patent applications. Furthermore, the proposal can create a dichotomy in the patent system, where companies that invest in cutting-edge research tools and use AI to invent may be at a disadvantage if they choose not to disclose their use of AI in their patent applications. In contrast, companies that are less efficient and do not invest in research tools may be favoured, as they may not face the same burden of disclosure.⁹⁰⁸ The concept of a “double standard” depending on whether the patent applicant declares the use of AI does not seem acceptable. This approach could lead to unfair treatment of inventors and may not be compatible with the principles of patent law, since it contradicts the key requirement of objectivising the judgment of the inventive activity, meaning that the evaluation of an invention should be based on the conditions in which a person skilled in the field, with all the known prior art, would have approached the objective technical problem that the patent aims to solve.⁹⁰⁹

Finally, it should be emphasized that the threshold for considering information and methods as common general knowledge is quite high. Therefore, if courts or examiners find it difficult to clearly identify the AI tools commonly used (and how they are used), it likely indicates that there is no such thing as a “normal” AI tool in the field. Part of this difficulty stems from the secrecy maintained by companies investing in AI innovation to avoid obviousness attacks, among other reasons.⁹¹⁰ However, over time, research trends and tools are likely to emerge with sufficient information to be incorporated into the skilled person’s model.

Ultimately, the determination of whether AI can be considered a “standard tool” without doubts or further research work is subjective and dependent on interpretation and perspective. It relies on factors such as the context, the specific form and model of AI, and the consensus within a given field or industry. The question arises whether a general approach can be established or if a case-by-case analysis is necessary. Given that the term “AI” encompasses a wide range of systems with varying capabilities, complexity, and constant evolution, it seems more appropriate to conduct a case-by-case analysis at present. While most AI systems are capable

⁹⁰⁶ Cody S D Wamsley, ‘Flashes of Genius, Toiled Experimentation, and Now Artificial Creation: A Case for Inventive Process Disclosures’ (LLM thesis, The George Washington University Law School 2011) 98, http://etd.gelman.gwu.edu/etd_11165/11165.pdf.

⁹⁰⁷ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 35 et seq.

⁹⁰⁸ Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 130 et seq.; Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 4.

⁹⁰⁹ Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale*, 130.

⁹¹⁰ Tim W Dornis, ‘Artificial Intelligence and Innovation: The End of Patent Law as We Know It’ (2020) 23 *Yale Journal of Law & Technology* 132.

of rapidly analysing massive amounts of data, establishing AI as a standard tool in a specific field faces challenges due to the fragmented technical landscape.

5. Alternatives to Identifying “Standard” AI Tools

Given the challenges in determining what constitutes a “general/standard/normal” AI tool, several alternative approaches have been proposed.⁹¹¹

Evaluating the exact AI tool used by the inventor (or a similar one) could simplify the assessment of the inventive step.⁹¹² However, this approach is problematic because inventors often do not disclose their specific methodologies, making it difficult to obtain relevant information.⁹¹³ Additionally, it risks hindsight bias by assuming that the tool used by the inventor is typical of what a skilled person would use, which might not be the case.

Determining the appropriate AI technology for the person skilled in the art and assessing its non-obviousness in achieving the inventive result would require further investigation, taking into account the problem-and-solution and the “could-would” approach.⁹¹⁴ The standard set by the “could-would” approach would be modified, as AI-related suggestions become recognizable beforehand, indicating that the invention *could* have been made by a human without AI assistance but likely *would* not have been made without AI assistance. This change would acknowledge the impact of AI in facilitating and enhancing the inventive process.⁹¹⁵ Thus, simply identifying the prevalence and specific applications of AI in the relevant field is not sufficient. It is also necessary to determine whether the identified AI technology is a standard equipment in the field. Using the best AI tool available could simplify defining a “normal” AI tool, but this approach conflicts with the idea that the skilled person has average capabilities.⁹¹⁶ While this may not impact the patentability of inventions using superior tools, it could disadvantage both developers of leading tools and their competitors.⁹¹⁷

⁹¹¹ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 238-241.

⁹¹² Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866.

⁹¹³ Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 17 et seq.

⁹¹⁴ For the purposes of the assessment of inventive step on the basis of the problem and solution approach, one must in fact reconstruct what the state of the art would have suggested to the person skilled in the art, not taking into account neither the inventor’s gap with these standards - and thus the fact that he subjectively engaged in an inventive step to make what was objectively not an invention, because it was obvious to the technician that that gap did not exist; nor, conversely, does the plus of skills and knowledge that the inventor concretely possessed and that made it obvious to him to arrive at the invention prevent that invention from being considered patentable, when the “normal” technician was not endowed with that plus (Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 128).

⁹¹⁵ Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 131 et seq.

⁹¹⁶ Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 17 et seq.

⁹¹⁷ Tim W Dornis, ‘Artificial Intelligence and Innovation: The End of Patent Law as We Know It’ (2020) 23 *Yale Journal of Law & Technology* 113; similarly, also Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866 et seq.

According to *Galli* and *Bogni*, an invention may be patentable if the result achieved would not have been obvious to the person skilled in the art, even if achieved using non-standard technology.⁹¹⁸ Assessing the inventive step by using the problem and solution approach requires reconstructing what the state of the art would have suggested to the person skilled in the art, by disregarding any non-standard technology or non-public knowledge possessed by the inventor that would have made the invention seem obvious to them but not to the average skilled technician.⁹¹⁹ The subjective gap between the inventor's knowledge and the state of the art should not be taken into account. Conversely, the inventor's additional skills and knowledge should not prevent the invention from being considered patentable if the average skilled technician lacked that same expertise.⁹²⁰

Abbott instead suggests that a patent should only be invalidated if it would be obvious using all considered tools, thereby continuing to reward innovation.⁹²¹ However, this approach has limitations; if a common tool makes the invention obvious, the inventive step is lacking, regardless of whether another tool would not lead to the same result. The existence of alternative tools that do not lead to the invention does not negate the fact that at least one tool does.

Another approach could be to have patent offices define a reference AI tool. These tools can be used to attempt to replicate an invention, with the idea that if the reference tools fail, the invention must be inventive. This approach has attracted attention in the literature and, at first glance, appears promising for increasing the efficiency of patent examination processes by leveraging AI. However, this approach is problematic as it has focused primarily on reference AI algorithms while largely ignoring the critical issue of the datasets on which these algorithms operate.⁹²² When defining reference datasets, values such as effectiveness, transparency, verifiability, and efficiency may be compromised, making this approach less attractive.⁹²³ The effectiveness of AI in patent examination heavily relies on the quality of the datasets it processes. Many publicly available datasets are often uncured, containing transcription errors, mislabelled units, and complex legal language that can mislead AI algorithms. This lack of structured data can significantly impair the predictive accuracy of AI tools, leading to unreliable assessments of inventiveness. The transparency of datasets is crucial for ensuring that AI

⁹¹⁸ Cesare Galli and Mariangela Bogni, 'Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach' (2020) 2 *Il Diritto industriale* 131.

⁹¹⁹ *Ibid*; Daniele Cerulla, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) 128.

⁹²⁰ For the purposes of the assessment of inventive step on the basis of the problem and solution approach, one must in fact reconstruct what the state of the art would have suggested to the person skilled in the art, not taking into account neither the inventor's gap with these standards - and thus the fact that he subjectively engaged in an inventive step to make what was objectively not an invention, because it was obvious to the technician that that gap did not exist; nor, conversely, does the plus of skills and knowledge that the inventor concretely possessed and that made it obvious to him to arrive at the invention prevent that invention from being considered patentable, when the "normal" technician was not endowed with that plus (Daniele Cerulla, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) 128).

⁹²¹ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 40.

⁹²² Christian Hartmann et al., 'Trends and Developments in AI. Challenges to the Intellectual Property Rights Framework. Final Report' (Publications Office of the European Union, 2020) https://www.ivir.nl/publicaties/download/Trends_and_Developments_in_Artificial_Intelligence-1.pdf.

⁹²³ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 44; Tim W Dornis, 'Artificial Intelligence and Innovation: The End of Patent Law as We Know It' (2020) 23 *Yale Journal of Law & Technology* 134; see also: Maurice Schellekens, 'Artificial Intelligence and the re-imagination of inventive step' (2022) 13(2) *JIPITEC* 95 et seq.

algorithms can be trusted to provide accurate results. If the datasets lack clarity or are not well-documented, it becomes difficult to verify the outcomes produced by the AI tools. This can lead to scepticism regarding their efficacy in distinguishing between inventive and non-inventive applications. A way to circumvent these issues could be by focusing on secondary indicators of inventiveness. However, it is unlikely that these secondary indicators can provide robust results.⁹²⁴

Thus, identifying “normal” AI tools for the skilled person will be a complex task, requiring evidence, expert opinions, and potentially experiments.⁹²⁵ As technology evolves, this process may become more manageable over time. For now, an approach as outlined in Section D.V.3 is advisable.

6. Further Considerations

Regardless of whether the inventor actually used AI, the inventive step of an invention must be assessed through a comprehensive analysis. This includes accurately identifying the technical field and state of the art, defining the skilled person and their common general knowledge, and determining whether the invention would have been obvious when considering all relevant factors. Structured approaches to the inventive step, such as the problem-and-solution approach provide useful methodologies for conducting this analysis.⁹²⁶

The use of AI as a tool introduces complex data-related issues in the context of patentability. The training data for AI algorithms must be distinguished from the data the AI uses to conduct prior art searches. While the training data used to develop AI models might influence how effectively an AI tool performs, the critical factor in patent examination is the AI’s ability to identify relevant prior art.⁹²⁷

The skilled person’s ability to use AI for patent searches raises questions about the completeness and accessibility of the data. In practice, the relevant prior art would typically be found in patent databases, scientific publications, and other established sources.⁹²⁸ However, it is unlikely that an AI system has access to “all” possible training data or all prior art documents. This limitation makes it crucial to define what constitutes “relevant” training data and the scope of prior art that the AI should consider. AI’s ability to effectively identify prior art is more important than the specific details of its training process.

Further complicating this issue is the need to balance disclosure requirements with confidentiality and data privacy concerns. AI models may rely on proprietary training data that

⁹²⁴ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.

⁹²⁵ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866 et seq.

⁹²⁶ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 225.

⁹²⁷ For a general discussion see: Andrea Ottolia, *Big Data e innovazione computazionale* (Giappichelli 2017).

⁹²⁸ Cesare Galli and Mariangela Bogni, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 132; Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 24.

cannot be fully disclosed in a patent application.⁹²⁹ While AI applications can have virtually unlimited memory capacity, the existing knowledge may still be incomplete or inaccessible due to privacy laws, confidentiality agreements, or the proprietary nature of certain datasets. This makes it essential to delineate the boundaries within which AI can operate as a tool for the skilled person, ensuring the inventive step is evaluated based on a reasonable and accessible body of prior art.⁹³⁰

7. Preliminary Results

The notional person skilled in the art is presumed to possess the means and capabilities necessary for conducting routine work within their technical field. These include standard tasks such as parameter setting, data preprocessing, and the selection of training and validation datasets. “Routine means” are defined as those tools, methods, and knowledge sources widely used and recognised in the field-spanning scientific literature, patent databases, and other accessible materials.

The actual empirical capacity of the skilled person, what they are capable of achieving, is not purely fictional. It reflects the practical abilities and constraints of real professionals operating in that domain. Although legal doctrine often characterises the skilled person as devoid of creativity, this presumption lacks statutory basis and should not obscure the reality that inventive capacity varies by field and context.

Determining what tools count as “routine” requires the same factual inquiry applied to assessing common general knowledge. The standard is not abstract technological possibility, but whether a method or tool was sufficiently known and reliable as of the priority date. This approach ensures that the inventive step analysis remains grounded in realistic assessments of time, cost, and likelihood of success.

This reasoning applies particularly to the adoption of AI tools by the skilled person. In fast-evolving technical domains, tools that were once novel may become standard. When AI is widely used in a field the skilled person may be expected to employ such tools in routine problem-solving. Consequently, AI-enabled practices can shift the boundary between the obvious and the inventive, depending on how widely those tools have been integrated into professional workflows. In this sense, the availability and routine use of AI systems can expand the skilled person’s toolkit. However, their use must be assessed in context: an AI tool constitutes a “routine means” only if, at the relevant priority date, it was reliably and predictably usable by average practitioners in the field. This underscores the need to distinguish between

⁹²⁹ For a summary on the subject of databases and an overview of doctrine and law see Estelle Derclaye, ‘The ECJ interprets the database *sui generis* right for the first time’ (2005) 30 *European Law Review* 420-430 passim; Stefania Lavagnini, ‘Commento sub artt. 64 quinquies e 64 sexies’ in Luigi C Ubertazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza* (6th edn, CEDAM 2016).

⁹³⁰ Kemal Bengi and Christopher Heath, ‘Patents and Artificial Intelligence Inventions’ in Christopher Heath, Anselm Kamperman Sanders, and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 141 et seq.

mere technical feasibility and established practice when evaluating inventive step in AI-driven innovation.

The assumptions underlying the person skilled in the art are therefore twofold: (i) a legal fiction about their access to globally available knowledge, and (ii) an empirical evaluation of their actual technical capacity. In emerging or interdisciplinary areas, including those involving AI, this second component becomes especially important. In such cases, the evolving practices and tools available to the average practitioner may significantly influence what is considered obvious or inventive.

III The Knowledge of the Person Skilled in the Art

In addition to outlining the importance of common general knowledge, this Section looks at three important points that are relevant when assessing AI-related inventions. Firstly, it considers the conditions under which the use of AI technologies, and knowledge of specific AI systems, can be regarded as part of the common general knowledge attributed to a person skilled in the relevant field. Secondly, it considers the extent to which human involvement in the deployment of AI systems, such as selecting input data or evaluating generated outputs, may contribute to an inventive step. Thirdly, it explores how the presence of an inventive step should be assessed in cases where an AI system, although part of the common general knowledge of the person skilled in the art, produces a result that would not have been obvious to a human skilled person operating without access to such an AI system.

1. The Common General Knowledge and its Legal Significance

The concept of common general knowledge is foundational to assessing inventive step under the EPC. The person skilled in the art is assumed to be aware of both the state of the art and the common general knowledge. The state of the art comprises all information made publicly available prior to the filing date, while the common general knowledge represents the body of knowledge so well established in the field that it can be used without doubt or extensive further investigation.

The common general knowledge is therefore a class of prior art and includes the knowledge that can be found in the main written disclosures in the field, including basic manuals, monographs, encyclopaedias, textbooks and reference books,⁹³¹ as well as unwritten knowledge, the so called “mental furniture” defined by case law of the BoA, which refers to the skills, practices, and knowledge that a skilled person in the relevant technical field would typically possess at the relevant date.⁹³² It is the “mental toolkit” of the skilled person, which is not necessarily documented but can be demonstrated in disputes.

⁹³¹ EPO, T 766/91, 29 September 1993 (*Decorative laminates/BOEING*), § 8.2.

⁹³² The BoA identifies three crucial elements to consider when evaluating the common general knowledge of a skilled person: “(a) Firstly, the skills of such a person include not only basic general knowledge of a particular field of technology, but also the ability to look up such knowledge in encyclopaedias and handbooks [...]; (b)

The BoA defines the common general knowledge as the knowledge that an experienced person in the field in question is expected to have, or at least to be aware of, to the extent that it knows it could look it up in a book if it needed it. While prior art can be explicitly cited in patent applications, common general knowledge is often implicit and not documented. Still, it should be usable without doubt or need for further research, meaning that if the knowledge is still experimental, or leaves an expert in doubt, it cannot be included. It is thus limited to the means and capacities of the person skilled in the art in question.⁹³³ Within this framework, the assessment of what constitutes common general knowledge is a factual question, depending on the invention considered and the level of development of the sector to which the invention relates.⁹³⁴

The fundamental aspects for assessing the common general knowledge of the person skilled in the art are: (a) the basic general knowledge of the particular field concerned, (b) the ability to find this knowledge in the appropriate sources, (c) to identify this common general knowledge by means of a literature search that need not necessarily extend beyond the person skilled in the art, and (d) the need for the information found to be unambiguous and usable in a direct and immediate manner without doubt or further research.

Importantly, not all prior art forms part of the common general knowledge. While both prior art and common general knowledge are considered in the assessment of the inventive step, they serve different roles. Prior art provides specific disclosures, while common general knowledge provides a broader context of what is known in the field.⁹³⁵ The mere fact that a document has been published does not imply that its content is widely recognised or routinely applied by practitioners within the relevant technical field. The skilled person is presumed to know of such disclosures, but will not necessarily interpret or apply them unless their relevance to the technical problem is apparent. This is because not all prior art carries equal relevance or is necessarily comprehensible to the hypothetical skilled person.⁹³⁶ Although this notional expert is presumed to be familiar with the state of the art, they do not treat all prior disclosures as equally pertinent to the problem at hand. The presence of individual elements of an invention in the prior art does not preclude inventiveness where the particular combination or application of those elements represents a non-obvious solution. The skilled person is assumed to have access to the entire state of the art and to consult adjacent technical fields, but typically refrains

Secondly, [...] in order to identify this common general knowledge, the skilled person will [not] carry out a comprehensive search of the literature covering virtually the whole state of the art. [...]; and (c) Thirdly, the information found must be unambiguous and usable in a direct and straightforward manner without doubts or further research work [...]”. (EPO, T 890/02, 14 October 2004 (*Chimeric gene/BAYER*), § 3). See also, for example: EPO, T 939/92, 12 September 1995 (*Triazoles/AGREVO*), § 2.3; Richard Davis, Thomas St Quintin and Guy Tritton, *Tritton on Intellectual Property in Europe* (5th edn, Sweet & Maxwell 2018) paras 2-151 et seq.; Pia Björk, ‘Inventive Step: The EPO Approach’ (EPO, 13 December 2016).

⁹³³ Kaisa Suominen et al., *Visser’s Annotated European Patent Convention* (Wolters Kluwer, Alphen aan den Rijn 2022) 206; EPO, T 890/02, 14 October 2004 (*Chimeric gene/BAYER*).

⁹³⁴ For example in EPO, T 676/94, 6 February 1996 (*Radial tyre/SUMITOMO*); the BoA ruled that for the expert dealing with the problem of bringing certain raw materials together, the conclusions of research on those materials, even if carried out by very few manufacturers, are still part of the relevant general technical knowledge, despite the fact that the studies in question have only been published in technical journals.

⁹³⁵ Bardehle Pagenberg, ‘Assessment of Inventive Step under the EPC’ (2021) 5-9 https://media.bardehle.com/contentdocuments/broschures/Assessment_of_Inventive_Step_under_the_EPC.pdf.

⁹³⁶ Dan L Burk and Mark A Lemley, ‘Is Patent Law Technology-Specific?’ 17(4) *Berkeley Technology Law Journal* (2002) 1178.

from considering prior art from remote disciplines unless there exists a clear and compelling reason to do so.

The assessment of novelty, inventive step, and sufficiency of disclosure heavily relies on the determination of what can be considered as common general knowledge.⁹³⁷ The EPO's problem-and-solution approach further ensures that only true innovations receive patent protection.⁹³⁸ It primarily relies on factual assessments of technical problems and the ways to solve them, which could be attributed to the objective knowledge and skills of a person skilled in the art as of the priority date, without any knowledge of the patent application or the invention itself.⁹³⁹

2. AI Systems as part of the Common General Knowledge

In patent applications, applicants often fail to disclose the specific AI systems or models used for an invention, which shifts the inquiry to whether such tools fall within the routine repertoire of the skilled person, judged against established common general knowledge criteria.⁹⁴⁰ As an alternative to imposing mandatory disclosure requirements concerning the role of AI in the inventive process, it may be more appropriate to evaluate whether such tools can be considered standard instruments within the repertoire of the skilled person, applying established principles governing common general knowledge.⁹⁴¹

In the context of patent law, AI cannot be categorised as *knowledge* in itself. Instead, it is considered a tool or a category of technical methods. Thus, in light of the expectation that AI will affect the knowledge attributed to the skilled person, it is important to clarify that AI programs do not inherently expand the knowledge attributed to the skilled person.⁹⁴² However, certain aspects of AI may be considered part of the common general knowledge of the skilled person at the relevant priority date. As previously seen, common general knowledge encompasses information, principles and practices that are generally accepted and routinely applied by practitioners in the relevant technical field. While an AI system in its entirety does not constitute common general knowledge, the skilled person's familiarity with specific AI techniques, such as convolutional neural networks for image recognition, or with established AI models, such as ChatGPT, may qualify as such. This is provided these techniques and models are well established and widely adopted in general and/or in the relevant field.

Where AI technologies are widely adopted, the capabilities they offer may become part of the skilled person's mental resources, thus they become part of the common general knowledge,

⁹³⁷ EPO, Case Law of the BoA 2022, I-C,2.8.1.

⁹³⁸ A Kennington, 'A Review of the "Problem and Solution" Approach to Inventive Step under Article 56 EPC' (2016) *epi (European Patent Institute) Information* 28 et seq., <https://information.patentepi.org/1-16/problem-solution-approach-article-56-epc.html>.

⁹³⁹ EPO, T 967/97, 25 October 2001 (*Chipkarte/OVD KINEGRAM AG*).

⁹⁴⁰ For more on "disclosure" see Part F.

⁹⁴¹ Justice Laddie defined the common general knowledge as "the technical background of the notional man in the art against which the prior art must be considered" (*Raychem Corp's Patents* [1998] RPC 31-40).

⁹⁴² Joel Nägerl, 'Abgrenzung vom Stand der Technik – Neuheit und erfinderische Tätigkeit', in M Haedicke and H Timmann (eds), *Handbuch des Patentrechts* (2nd edn, Munich 2020) § 84 [18].

meaning that they will be considered part of the state of the art for those fields.⁹⁴³ This would require the person skilled in the art to have knowledge of AI technology and its application in the relevant field, which would ensure that the person can understand and evaluate inventions that involve AI. Since AI is advancing, the level of skills and knowledge required for a person skilled in the art needs to be adapted to the priority date of the invention.⁹⁴⁴ The skilled person in a particular field has access to the routine work and experimentation typical of that field: if AI is used in that field, the skilled person will use it and its skills will reflect that.⁹⁴⁵ If all inventors in a given field have access to AI, it is reasonable to assume that any technician in the field and thus the expert responsible for evaluating the inventive activity would have knowledge of AI technologies.⁹⁴⁶

For an AI system to be deemed common general knowledge, it must be known and used in such a way that its application does not require further invention or investigation. The fact that a specific AI tool is known or even published does not suffice: its use must be so prevalent and routine that it would be considered an expected component of the skilled person's toolkit. Conversely, the specific implementation details of an AI model, such as its architecture, training dataset, hyperparameter values or bespoke optimisation techniques, will not usually form part of common general knowledge unless they are also standardised and widely known.

For instance, if AI-assisted data analysis is standard in genomics, then the person skilled in the art may be expected to use AI tools in that context. However, even if AI allows the identification of patterns or correlations not immediately apparent to a human, this does not necessarily render such insights part of common general knowledge. Discoverability through AI must be distinguished from the knowledge that is directly accessible and usable by a human expert without undue effort. This is only the case if such AI-related information is readily discoverable and usable for solving specific problems from the skilled person's perspective.⁹⁴⁷ Furthermore, the presence of certain technical relationships within the skilled person's knowledge does not necessarily imply that it is obvious for the skilled person to use this knowledge to solve a

⁹⁴³ Noam Shemtov and Garry Gabison, 'The Inventive Step Requirement and the Rise of the AI Machines' in R. Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.; EPO, 'Comments on the Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence' (WIPO Conversation on IP and AI, Second Session, 7-9 July 2020) 8, where it is stated that the skilled person has at their disposal the means and capacity for routine work and experimentation which are normal for the field of technology in question. Accordingly, if AI is used in the relevant field of technology, it will be used by the skilled person and their skills will rise accordingly.

⁹⁴⁴ Daryl Lim, 'AI & IP: Innovation & Creativity in an Age of Accelerated Change' (2018) 52 *Akron Law Review* 863.

⁹⁴⁵ EPO, 'Comments on the Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence' (WIPO Conversation on IP and AI, Second Session, 7-9 July 2020) 8.

⁹⁴⁶ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 6 (stating that "machines are already augmenting the capabilities of workers, in essence making more obvious and expanding the scope of prior art"); Susan Y Tull and Paula E Miller, 'Patenting Artificial Intelligence: Issues of Obviousness, Inventorship, and Patent Eligibility' (2018) 1(5) *Journal of Robotics, Artificial Intelligence and Law* 320; Erica Fraser, 'Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law' (2016) 13(3) *SCRIPTed* 320 et seq.; Liza Vertinsky and Todd M Rice, 'Thinking about thinking machines: Implications of Machine Inventors for Patent Law' (2002) 8(2) *Boston University Journal of Science and Technology Law* 595 (referring to an increase in the capabilities of the skilled person equal to those of a machine).

⁹⁴⁷ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 312-313.

specific technical problem. Thus, the influence of AI advancements on the knowledge of the skilled person is expected to be limited.⁹⁴⁸

Therefore, in terms of the obviousness assessment, while the existence and general applicability of AI tools may be considered part of common general knowledge, this does not render any specific AI-based solution obvious in itself. Instead, the assessment must determine whether moving from general awareness of the tool to the claimed technical implementation would have been within the routine capabilities of the skilled person or would have required the exercise of inventive skills. Therefore, a thorough assessment of whether an AI tool may be regarded as part of the common general knowledge accessible to the person skilled in the art necessitates deeper examination.⁹⁴⁹ Analogy to databases must also be applied cautiously. AI does not merely retrieve known information; it can generate novel outputs through complex and opaque internal processes. Therefore, outputs from AI systems, even if derived from known data, are not automatically attributable to common general knowledge unless they have entered the collective technical understanding of the field.

3. Inventive Human Contributions in the Use and Application of AI Tools

Even where AI systems are part of the common general knowledge, human engagement with these tools may still give rise to inventive step. The inventive activity may lie not in the mere deployment of AI, but in how the AI is used, configured, or interpreted. This includes, for example, the careful selection of training data, fine-tuning of parameters, or the informed evaluation and filtering of outputs.

Human tasks such as designing the input structure, selecting relevant datasets, or setting meaningful parameters often require domain-specific expertise and creativity. These tasks are typically not automated and can contribute to inventive step when they go beyond routine experimentation. In particular, the selection of certain outputs among many generated by an AI system, where this selection is neither trivial nor dictated by prior art, can reflect a non-obvious technical contribution.

It is therefore essential to distinguish between the mechanical use of AI and its application involving non-trivial human input. The problem-solution approach, as employed by the EPO, accommodates such distinctions: while the person skilled in the art is deemed capable of conducting routine experiments or using standard tools, inventive step is recognized where these activities yield a technical solution not obvious in view of the prior art.

The use of AI tools does not obviate the need for inventive step. Instead, the focus shifts to whether the human intervention in deploying the tool led to a non-obvious technical effect. The

⁹⁴⁸ Ibid, 314.

⁹⁴⁹ Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 71; see also: Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 17 (suggesting to use “best” machine learning tool available); Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 125-130 (discussing the difficulties in determining the “standard” AI system for the assessment of the inventive step).

legal framework must be sensitive to the nuanced roles that human users play in guiding and interpreting AI outputs. A sophisticated use of AI, such as developing a new training protocol or configuring a neural network to yield novel technical results, can meet the threshold for inventiveness when it goes beyond what is predictable or routine for the skilled person.

Thus, while AI tools themselves may be common general knowledge, the inventive step can lie in the manner of their application. The evaluation must be based on whether the skilled person, even if equipped with common general knowledge and standard AI tools, would have arrived at the claimed invention in an obvious way.

4. Preliminary Findings

Common general knowledge refers to well-established information in a technical field and is distinct from general prior art. This includes both documented sources, such as textbooks and manuals, and undocumented expertise, or “mental furniture”. The skilled person is presumed to apply such knowledge without undue effort. Not all prior art is part of this common knowledge: its inclusion is assessed on a case-by-case basis depending on the field and development stage of the invention.

Despite being powerful, AI tools do not inherently expand the knowledge attributed to the skilled person. For an AI system to be considered part of common general knowledge, it must be widely used and understood in the relevant field. The focus is on routine familiarity and standard application, rather than mere availability or publication. AI outputs are not automatically part of the skilled person's knowledge unless they have become integrated into the field's technical understanding.

IV. “Obvious” to the AI-Skilled Person

1. Distinguishing Method from Outcome in Obviousness Assessments

A complex issue arises when an AI system produces results that a human would not have found obvious, given that it forms part of the common general knowledge. Such results may be considered obvious because the AI system is assumed to be within the toolbox of a skilled person and was able to generate them. Alternatively, the difference between human intuition and AI output may be seen as warranting recognition of an inventive step.

Under the problem-solution approach, the key question is whether the skilled person, in possession of the prior art and common general knowledge, would have arrived at the claimed invention in an *obvious* way. Patent examiners assess whether an invention would have been “obvious” to a person skilled in the relevant field, meaning that it would merely follow plainly or logically from the prior art and therefore lack an inventive step.⁹⁵⁰ Once AI-models and related skills become part of the common general knowledge, patent examiners and courts must determine the appropriate level of expertise taking them into consideration. Otherwise, when

⁹⁵⁰ EPO Guidelines 2025, Part G-VII, 4.

AI achieves results that may not be obvious to a skilled person, questions arise regarding the level of inventiveness of the invention, since AI-related inventions may introduce technical features and algorithms unfamiliar to a person skilled in the art that does not use AI.⁹⁵¹

This presents a particularly complex aspect of assessing obviousness, as the height of the obviousness bar is determined by the level of common general knowledge.⁹⁵² Setting the skill level too high may render most inventions obvious, whereas setting it too low risks circumventing the obviousness hurdle while inviting insufficiency objections. Therefore, accurately determining the scope and level of common general knowledge is essential in assessing obviousness.

An invention may be denied an inventive step if a skilled person could have arrived at it using the AI technologies considered common general knowledge at the relevant priority date.⁹⁵³ As a result, future AI-related inventions might only be patentable if the use of AI in that specific technological context was itself non-obvious, or if the AI system used significantly differed from those generally available at the time, or was adapted in a non-obvious manner and interacted uniquely with other technical features in the claim.⁹⁵⁴ This perspective shifts the focus of the inventive step analysis away from the invention itself and towards the tools used in its development. The emphasis on the inventive process over the inventive product introduces a genealogy-based assessment of patentability, which poses significant conceptual and practical challenges.

A critical but often overlooked dimension of this shift concerns the distinction between the skilled person's knowledge of a tool and their knowledge of the tool's possible outputs. For example, in a particular area of medicine, it may be well established, indeed part of the common general knowledge, that a specific AI system, such as system X, is routinely used for drug discovery purposes. The system is publicly available, and its use has become a standard part of the field's methodological repertoire. However, if a researcher uses X in a conventional, known way and, through that process, identifies a novel and unexpected compound, it is not immediately clear whether this result should be deemed obvious. The problem is compounded by the fact that outputs generated by such AI systems are frequently non-deterministic and may not be reproducible on demand. Consequently, the mere fact that the tool itself is part of the skilled person's knowledge base does not necessarily imply that its specific outputs would have been obvious to them. Equating knowledge of the tool with knowledge of its results risks conflating two analytically distinct aspects of the inventive step inquiry: the methodological path and the substantive outcome. This distinction becomes particularly important in light of the increasing use of generative or stochastic AI systems in technical fields where results may emerge in unpredictable ways.

⁹⁵¹ William Samore, 'Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?' in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018) 129 et seq.; Ana Ramalho, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 1 et seq.

⁹⁵² For the UK see: *Conor Medsystems Inc v Angiotech Pharmaceuticals Inc* [2006] EWHC 260 (Pat), § 35.

⁹⁵³ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 311 et seq.

⁹⁵⁴ Ibid.

Furthermore, the broader emphasis on AI itself risks simplifying the role that AI plays in the inventive process, potentially overlooking contributions that merit legal recognition and incentive under patent law. The use of AI in invention is often shaped by a variety of contingent and individual factors, making it difficult to define a “standard” AI application.⁹⁵⁵ Overly narrow definitions of AI usage risk introducing a retrospective bias that only considers what was known to the average skilled person at the priority date, which ought to be avoided.⁹⁵⁶

The EPO should consider adapting the evaluation of obviousness in light of AI’s increasing presence in certain technological domains. Patent examiners should assess factors such as the extent to which the research process reflects routine implementation of prior art, the nature and necessity of value judgments exercised by the skilled person in applying that prior art, and the foreseeability of success. While this could enhance procedural efficiency, it also risks disadvantaging applicants, particularly small entities or individual inventors, who do not have access to advanced AI tools.⁹⁵⁷ Such contextual factors are essential for assessing obviousness in AI-related inventions, but only inventive applications of AI should be eligible for patent protection. The foreseeability of the research outcome, in particular, may serve as a proxy for whether a skilled person would likely have pursued a given AI-based approach.

If, in the future, machines or AI systems were to be considered inventors, the obviousness standard would face further complications.⁹⁵⁸ Examiners would then be required to assess whether the invention would have been obvious not only to a human skilled in the art but also to the AI system itself. This would necessitate a comprehensive understanding of the capabilities and knowledge base of all potential (human and non-human) inventors, a task that appears increasingly untenable as AI systems become more sophisticated. Establishing a coherent and practical standard for inventive step under such circumstances would be both technically and administratively burdensome.⁹⁵⁹

There is, therefore, a pressing need to reflect on the human examiner’s capacity to evaluate obviousness under these evolving conditions, even when assisted by AI tools in the examination process.⁹⁶⁰ As the body of prior art grows and AI’s technical capabilities advance, the risk

⁹⁵⁵ Tim W Dornis, ‘Künstliche Intelligenz und Innovation – Perspektiven der Disruption im Patentrecht (Teil 1)’ (2020) *Mitteilungen der deutschen Patentanwälte* 444.

⁹⁵⁶ Joel Nägerl, ‘Abgrenzung vom Stand der Technik – Neuheit und erfinderische Tätigkeit’, in M Haedicke and H Timmann (eds), *Handbuch des Patentrechts* (2nd edn, Munich 2020) § 4 [29]; Christian Heinze and Andreas Engel, ‘KI und Patentrecht’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 63.

⁹⁵⁷ Adapting the PHOSITA standard to account for AI capabilities could help level the playing field between large and small inventors. This could serve the incentive purpose of the patent system by encouraging innovation from smaller entities. There is precedent for the USPTO adapting patent requirements based on entity size, as seen with the tiered fee structure you mentioned. This suggests there may be openness to considering entity size in other aspects of patent law (USPTO, ‘USPTO Fee Schedule’ <https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule>).

⁹⁵⁸ Jeremy A Cubert and Richard G A Bone, ‘The Law of Intellectual Property Created by Artificial Intelligence’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 421.

⁹⁵⁹ Sven Hetmank and Anne Lauber-Rönsberg, ‘Künstliche Intelligenz – Herausforderungen für das Immaterialgüterrecht’ (2018) *GRUR* 580 et seq.

⁹⁶⁰ Martin Stierle, ‘A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System’ (2021) *GRUR International* 129.

emerges that almost any invention could retrospectively be considered obvious.⁹⁶¹ Addressing this issue demands a more refined and adaptive framework for assessing inventive step, one that integrates conventional legal standards with new considerations specific to AI technologies. This framework should define, with precision, what constitutes common general knowledge concerning AI tools and their usage within a particular technical field. It should also account for contextual variations in AI implementation across industries and ensure that access disparities do not penalize inventors lacking sophisticated tools. Ultimately, the focus must remain on rewarding inventive uses of AI, those applications that are non-obvious and contribute meaningfully to the claimed invention's technical character. To that end, continuous training for patent examiners on emerging technologies, especially AI, will be essential to maintaining consistency and rigour in patentability assessments.

Still, while the skilled person may be equipped with AI tools, they are not omniscient, nor are they to be equated with the AI itself. The threshold for obviousness must reflect the reality that certain AI-related outcomes are qualitatively different from what a human would predict or derive through standard reasoning. Ultimately, AI reshapes the context in which the skilled person operates. The use of AI may assist in the invention process, but where it leads to insights beyond foresight, the standard of obviousness must adapt accordingly.

2. The Reasoning in T 1439/09

Evaluating the *ex post* obviousness of certain paths in AI-related inventions can be challenging, especially when the process used to find the invention is not fully disclosed. This is because the computational process leading to the invention may involve numerous non-trivial decisions, making it challenging to determine if the end result was genuinely obvious.

An instructive case in this context is T 1439/09, which was argued, amongst others, on the ground of obviousness of the process needed to arrive at the claimed invention.⁹⁶² The case involved a process for identifying anti-sclerostin antibodies for the treatment of osteoporosis.⁹⁶³ The appellant argued that a skilled person, using standard computational tools and data, could have followed a straightforward path to arrive at the claimed invention, essentially characterizing the process as routine data parsing and gene prediction.⁹⁶⁴

The core of the dispute was whether the process was *obvious* to a skilled person or involved multiple non-trivial decisions. The appellant asserted that a skilled person, utilising standard computer skills and available data, could have navigated the process efficiently. They argued that simply parsing a database and using a gene prediction program constituted routine work.⁹⁶⁵ In contrast, the respondent contended that the process entailed numerous non-trivial decisions and required subjective assessments informed by domain-specific knowledge.⁹⁶⁶ The BoA

⁹⁶¹ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 34.

⁹⁶² EPO, T 1439/09, 16 April 2013 (*Sclerostin/UCB PHARMA*), § 25.

⁹⁶³ *Ibid.*, § 25 et seq.

⁹⁶⁴ *Ibid.*

⁹⁶⁵ EPO, T 1439/09, 16 April 2013 (*Sclerostin/UCB PHARMA*) § 33-42.

⁹⁶⁶ Francesca Mazzi, 'Patentability of AI Generated Drugs' (2020) 4(1) *EPLR* 24-25.

concluded that, although a skilled person could theoretically reach the invention, it was only with hindsight that the solution appeared evident. Applying the problem-and-solution approach starting from a specific prior art document (D3), the BoA found that the inventive process involved a series of non-obvious steps, each requiring specific judgments.⁹⁶⁷ The BoA concluded that the computational approach suggested by the appellant could have led to various solutions and required multiple non-trivial decisions. While it was possible for a skilled person to make the right decisions at each stage, it was only evident with hindsight that this would lead to the claimed invention.⁹⁶⁸ Crucially, it reaffirmed that the central issue is not whether the skilled person could arrive at the invention, but whether they would have had a reasonable expectation of success. In this case, the invention was ultimately found to involve an inventive step.⁹⁶⁹

A closer analysis reveals that the invention was the result of a causally controllable sequence of human actions involving deterministic computer technologies. Each stage of the process, system deployment, intermediate interpretation, decision-making, was under human control and, importantly, reproducible. Through an a *contrario* interpretation, the decision appears to suggest that, when instructions provided to a machine are inconclusive and the machine autonomously selects from different options, the resulting invention may be considered *obvious* because the machine, rather than a skilled person, is performing the inventive activity. Including AI, this line of reasoning introduces additional complexities.⁹⁷⁰ It becomes challenging to assess the degree of human involvement in the decision-making process, particularly when the procedural steps are undisclosed, obscuring whether the invention stems from the user's deliberate guidance or the AI system's independent operation.⁹⁷¹

In contrast, AI systems that autonomously generate hypotheses or results often function as “black boxes”, discovering correlations or solutions in ways that are not fully explainable or replicable by their human users. This difference is particularly relevant for the inventive step assessment: if an AI system independently uncovers a novel compound or technical solution in a way that cannot easily be traced or replicated, it challenges the assumption that the skilled person, constructed as a human agent, could have reasonably foreseen the outcome. The non-deterministic nature of such systems introduces a form of uncertainty that is not captured by the traditional test based on human reasoning and incremental logic. As a result, relying on T 1439/09 as a direct precedent for AI-related inventions risks obscuring this fundamental divergence in how inventive activity is conceptualized.

The decision thus illustrates how the traditional inventive step doctrine continues to emphasize human judgment and decision-making, even when advanced technologies are involved. It also signals the need for caution when extending these principles to AI-related inventions. While the traditional framework remains formally applicable, its doctrinal assumptions may be ill-suited for evaluating non-deterministic invention processes driven by AI. Particularly where

⁹⁶⁷ Ibid.

⁹⁶⁸ EPO, T 1439/09, 16 April 2013 (*Sclerostin/UCB PHARMA*) § 33-42.

⁹⁶⁹ Francesca Mazzi, ‘Patentability of AI Generated Drugs’ (2020) 4(1) *EPLR* 24-26.

⁹⁷⁰ Ibid.

⁹⁷¹ Ibid.

the inventive path is opaque, unpredictable, or unrepeatable, the standard for obviousness may need to be recalibrated to account for these epistemic and procedural differences.

3. From “Obvious to Try” to “Reasonable Expectation of Success” through AI-

Applying the “obvious to try” and “reasonable expectation of success” standards to AI-related inventions introduces specific difficulties in the inventive step analysis.⁹⁷² The use of AI tools can significantly accelerate experimentation and expand the number of testable hypotheses. As a result, scenarios where a solution is “obvious to try” may arise more frequently. However, this alone does not necessarily lead to the conclusion that the invention is obvious.

The argument that the application of AI increases the likelihood of success and hence reduces inventiveness is analytically flawed. While AI systems can identify correlations and process vast datasets beyond human capacity, this does not imply that a skilled person automatically has a higher expectation of success.⁹⁷³ Familiarity with AI tools and their use in daily practice does not render outcomes obvious, particularly when the tools themselves incorporate elements of unpredictability.⁹⁷⁴

Certain AI methods, such as evolutionary algorithms, involve inherent randomness. In T 737/96, the EPO held that such stochastic methods resemble a lottery and cannot provide a reliable basis for a reasonable expectation of success.⁹⁷⁵ Although the invention in that case was ultimately found to lack an inventive step due to its routine nature, the case illustrates the doctrinal tension when randomness and automation are involved.⁹⁷⁶ The potential for AI-related inventions to result from chance may, in some cases, support an argument for inventiveness.

A more economic-oriented argument is offered by *Shemtov* and *Gabison*, who suggest that AI-enabled research may become “economically rational”, and thus “obvious to try”, due to reductions in cost and time.⁹⁷⁷ They propose that the prevalence of AI tools in a field could lower the inventive threshold, even where the success expectation remains modest. While not yet reflected in EPO doctrine, this view aligns with broader trends in patent law that recognise economic feasibility as a relevant consideration.⁹⁷⁸

Ultimately, the decisive question remains whether the skilled person would have pursued the AI-based approach with a reasonable or fair expectation of success. If a particular AI-assisted research route appears merely hopeful, it may not render the invention obvious. If the route is judged as having a reasonable likelihood of success, based on the knowledge, tools, and standard practice at the time, then the invention may be found lacking in inventive step. This can be assessed by evaluating the project’s complexity, duration, decision points, and the

⁹⁷² Francesca Mazzi, ‘Patentability of AI Generated Drugs’ (2020) 4(1) *EPLR* 26-27.

⁹⁷³ Dan L Burk, ‘AI Patents and the Self-Assembling Machine’ (2021) 105 *Minnesota Law Review Headnotes* 9.

⁹⁷⁴ *Ibid.*

⁹⁷⁵ EPO, T 737/96, 9 March 2000 (*Astaxanthin/DSM*).

⁹⁷⁶ *Ibid.*, § 10(b).

⁹⁷⁷ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 434.

⁹⁷⁸ *Ibid.*

maturity of the relevant field. Even if a particular AI-based approach becomes economically rational, the invention may still be considered non-obvious if the skilled person could not reasonably predict success.

This reasoning is consistent with the “inducement standard” articulated by the US Supreme Court in *Graham v John Deere Co.*, which emphasises that patent protection is justified only where the invention would not have been developed without the incentive of a patent.⁹⁷⁹ Therefore, if a particular research path becomes economically feasible due to its cost-effectiveness and speed, patent protection may not be justified if the patent incentive was not necessary for the invention's creation. Whether mere disclosure suffices to warrant a patent in such cases will depend on the specifics of the invention.⁹⁸⁰

Thus, for AI-related inventions, the “obvious to try” formula may become a key factor in evaluating obviousness. Once AI tools and techniques are considered, an invention may become obvious. The key question is whether it was obvious to follow a particular route of research that involves AI tools, techniques, and expertise, and the expectation of success is a significant consideration. An (actual) research team may pursue various research routes (including an AI route) with nothing but hope to succeed. If such a route leads to the invention, the invention may not be considered obvious. However, the skilled person would pursue such a route if they judged it to have a reasonable or fair expectation of success. The expectation of success per se would render the invention obvious.

4. Preliminary Results

The integration of AI into inventive processes challenges traditional standards for assessing obviousness, particularly the role of the skilled person. When AI tools form part of the common general knowledge, a central difficulty is distinguishing between the knowledge of the tool itself and knowledge of its possible outputs. While the use of AI may be routine, its non-deterministic or stochastic outputs can lead to results that a human skilled in the art would not have predicted or considered obvious.

The conventional problem-and-solution approach remains applicable but must account for the level of expertise implied by AI-assisted/generated processes. A higher skill threshold risks making most inventions appear obvious, whereas a lower threshold may compromise the requirement for sufficiency. This calls for a refined understanding of what constitutes common general knowledge concerning AI systems, as well as a contextual assessment of their use across different industries.

Case law, such as T 1439/09, illustrates the continued emphasis on human judgment in determining obviousness, even where computational tools are used. However, this approach may not be adequate for AI-related inventions, especially when the AI functions as a “black

⁹⁷⁹ *Graham v John Deere Company* 383 US 1, 11 (1966) (US Supreme Court).

⁹⁸⁰ *Ibid.*

box”. In such cases, the predictability and reproducibility of the inventive process become important factors in determining whether the invention was obvious.

The “obvious to try” and “reasonable expectation of success” standards become more complex in the context of AI. While AI accelerates experimentation, its outcomes often remain uncertain. Thus, the mere application of AI does not necessarily reduce the threshold for inventiveness unless the skilled person could reasonably expect success from pursuing that particular AI-driven route.

The nature of some AI methods, as recognised in T 737/96, supports this position. As AI becomes embedded in research practices, there is a risk of retrospective reasoning, where inventions are deemed obvious simply because they could have been generated using available AI tools.

A more adaptive framework is needed—one that recognises the inventive contribution of using AI in non-obvious ways and accounts for the limitations of both human and AI inventors, as well as the person skilled in the art. The evolving role of AI therefore necessitates particular attention to the foreseeability of results, access disparities, and the methodological opacity of AI systems.

V. Revisiting the Identity of the “Person” Skilled in the Art in Light of AI

1. Implications on the “Human” Person Skilled in the Art

The integration of AI in the invention process may raise questions about the level of human involvement and contribution required for an invention to be considered non-obvious. AI has dramatically increased the actual skill setting of ordinary inventors as computers can be used as replacements for certain human inventive activities.⁹⁸¹ The application of AI techniques in various technological domains has undeniably influenced practitioners’ knowledge, skills, and problem-solving approaches. Since AI can override human intuition with the strength of computational power, the skilled person may need to be adapted, including the capability of AI, to ensure that the requirement of an inventive step meets its purpose.⁹⁸²

As previously discussed, the traditional definition of a person skilled in the art, as outlined in the EPC, is based on the notion that a - *person* - has the necessary knowledge and experience required to comprehend and assess the technical subject matter of a patent application.⁹⁸³ The introduction of AI in the inventive process poses the question of whether the definition of a

⁹⁸¹ William Samore, ‘Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?’ in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018).

⁹⁸² Clifford Chance, ‘AI and Patents – “the person skilled in the art”’ (Clifford Chance Talking Tech, 6 August 2019) <https://www.cliffordchance.com/insights/resources/blogs/talking-tech/en/articles/2019/08/ai-and-patents-the-person-skilled-in-the-art.html>.

⁹⁸³ Liza Vertinsky and Todd M Rice, ‘Thinking about thinking machines: Implications of Machine Inventors for Patent Law’ (2002) 8(2) *Boston University Journal of Science and Technology Law* 600-613 passim; Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 489.

person skilled in the art as it currently stands is adequate. It should always be kept in mind, that AI is an “umbrella” term, that includes various very different techniques and describing AI as a monolith can be problematic.⁹⁸⁴

Still, the general use of AI complicates identifying who the “person skilled in the art” would be. However, adjusting the inventive step requirement by considering AI’s influence is crucial to avoid disadvantaging “pure” human inventors amidst the rise of AI-related inventions. To prevent discouraging human inventors, the inventive step criterion should evolve to account not only for personal knowledge and skills but also for AI tools accessible to the inventor.⁹⁸⁵ As these technologies become more widespread in the inventive process, it becomes more plausible to assume that any technician in the field would have access to them, thus situating them within the reach of the skilled person.⁹⁸⁶ The higher the attributed skill level of this person, the more likely an invention will be considered obvious.

Addressing the impact of AI on the definition of the skilled person and the assessment of what is deemed obvious is essential. While it is inevitable that AI will become part of the inventive step analysis, careful consideration is required to set the non-obviousness threshold appropriately. If set too high, valuable inventions may become unpatentable, potentially stifling innovation. Conversely, if the threshold is too low, a surge of low-quality patents could lead to increased invalidity lawsuits, thereby disincentivising innovation.⁹⁸⁷ The most promising solution seems to involve integrating expertise from the specific domain alongside the application of AI within that context.⁹⁸⁸

Looking toward the future identity of the person skilled in the art, several options are open to debate. The first is to maintain the current system. The second proposes replacing the human “person” with a “machine” and thus introducing a “machine skilled in the art” approach (see Section D.V.2). The third suggests that the “person” should possess AI-related skills and possibly function as part of a team that includes an AI system, thus a “Skilled Person 2.0” (Section D.V.3).

2. Debating a “Machine Skilled in the Art” Approach

A proposal put forward in literature is that when AI becomes the primary means of research and is capable of inventing “autonomously”, the standard of inventiveness should be remodelled on the machine alone, to be consistent with an innovation market dominated by AI-

⁹⁸⁴ Tabrez Y Ebrahim, ‘Artificial Intelligence Inventions & Patent Disclosure’ (2020) 125(1) *Penn State Law Review* 151; Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 227.

⁹⁸⁵ Robert Plotkin, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business* (Stanford University Press 2009) 51 et seq.

⁹⁸⁶ William Samore, ‘Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?’ in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018) 128 et seq.

⁹⁸⁷ Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law’ (2018) 39 *Cardozo Law Review* 2215.

⁹⁸⁸ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 864.

related inventions and the processing and “creativity” capabilities of machines (expressions such as “machine skilled in the art”, “inventive machine”,⁹⁸⁹ “thinking machine”⁹⁹⁰ or “machine of ordinary skill in the art”, also “MOSITA” appear).⁹⁹¹ Various approaches have been elaborated.

a) *Abbott’s Approach*

The notion of a “machine skilled in the art” was first introduced by *Abbott* in 2018. He elaborates the notion of a “machine skilled in the art” as a construct that would substitute the classic “person skilled in the art” with a “thinking” machine to which eventually “everything [will be] obvious”.⁹⁹² *Abbott* has since then been an advocate for machines to be recognised as inventors by patent offices around the world, acting as an advisor and counsel in the various DABUS proceedings. In his reasoning, a “machine skilled in the art” would enable AI systems to be considered as proper inventors and not just tools used by human inventors.⁹⁹³

In *Abbott’s* definition, the “machine skilled in the art” is an AI system that has been trained on a particular technical field and is able to generate inventive solutions to technical problems in that field. This would involve the development of an AI system that is capable of understanding the technical subject matter of a patent application and assessing its patentability, in a similar manner to a human skilled in the art.⁹⁹⁴

Initially *Abbott* proposed to distinguish between a “skilled” AI, describing the average technician whose ingenuity is limited and more predictable, functioning within the boundaries of its programming and data inputs, and an “inventive” AI, describing an AI capable of creative thinking, going beyond routine problem-solving to generate patentable results.⁹⁹⁵

Still, the distinction between skilled AI and inventive AI may be challenging. Not only is it difficult to differentiate between the two, but the analysis may also be overly focused on the

⁹⁸⁹ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 26 et seq.

⁹⁹⁰ Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 502 (stating that policymakers may need to evaluate whether the definition of the person having ordinary skills in the art should be revised to encompass “thinking machines”); on the subject see also: Jeremy Cubert and Richard Bone, ‘The Law of Intellectual Property Created by Artificial Intelligence’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 421.

⁹⁹¹ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 31; Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 100 et seq.; Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 690 et seq.; Peter M Kohlhepp, ‘When the Invention is an Inventor: Revitalizing Patentable Subject Matter to Exclude Unpredictable Processes’ (2009) 93(2) *Minnesota Law Review* 779 (stating that “as technology continues to accelerate, research, discovery, and design work increasingly depend on computer programs to do not only the number-crunching but also the ‘thinking’”).

⁹⁹² Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1087-1088.

⁹⁹³ *Ibid.*

⁹⁹⁴ Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 502; Michael McLaughlin, ‘Computer-Generated Inventions’ (2019) 101 *Journal of Patent & Trademark Office Society* 224 et seq.

⁹⁹⁵ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 31.

capabilities of the machine skilled in the art rather than the technical merit of the finding.⁹⁹⁶ Given the generalisation of AI, a proposed solution would be to replace the skilled AI with inventive AI.⁹⁹⁷ This approach would raise the threshold of patentability, meaning that for an AI-related invention to be patentable, it would have to be non-obvious to an inventive AI, based on the state of the art.⁹⁹⁸ This approach avoids the complexity of distinguishing between skilled and inventive AI and focuses on the technical merit of the invention itself.⁹⁹⁹ Still, this raises several questions, one of them being how to determine which AI system should be considered inventive, especially for a specific type of invention or field.¹⁰⁰⁰

b) The “Machine Skilled in the Art” as Multiple Specific AIs

Another approach would be to define the machine skilled in the art with multiple specific AIs. The standard of the machine skilled in the art could be represented by widespread AIs such as DeepMind and Watson.

If both AIs determine that an invention is obvious, it could be considered non-patentable. This scenario suggests a rigorous standard where consensus among advanced AIs indicates a lack of inventiveness, reflecting a collective understanding of prior art and predictable outcomes. Conversely, if only one AI finds an invention to be obvious while the other does not, the invention would not be patentable.

However, this approach risks setting excessive requirements for an inventive step. Understanding each AI’s reasoning process and capabilities would be difficult. The legal system may struggle to interpret outputs from machines that operate differently from human reasoning. There are significant technical and legal challenges associated with the creation and implementation of such an automated system, and it remains unclear whether such a system could ever fully replicate the capabilities and knowledge of a human skilled in the art.

c) Duplicating the Invention by Using a Reference Algorithm and Dataset

Another approach would be by attempting to duplicate the invention using a reference algorithm and dataset, this method makes use of the automation of the inventive process to provide a clear picture of the invention’s non-obviousness as of the relevant date.¹⁰⁰¹ This approach is similar

⁹⁹⁶ Ibid, 32.

⁹⁹⁷ Ibid, 33 (“inventive is the new skilled”).

⁹⁹⁸ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 31.

⁹⁹⁹ Ibid, 34.

¹⁰⁰⁰ Jonathan J Darrow, ‘The Neglected Dimension of Patent Law’s PHOSITA Standard’ (2009) 23 *Harvard Journal of Law & Technology* 234 et seq.; Liza Vertinsky and Todd M Rice, ‘Thinking about thinking machines: Implications of Machine Inventors for Patent Law’ (2002) 8(2) *Boston University Journal of Science and Technology Law* 104; Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 320; Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 3.

¹⁰⁰¹ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 42-44; see also: Noam Shemtov, speaking at: EPO conference ‘Patenting AI’, 30 May 2018, Panel discussion 4 ‘Ethical and societal considerations

to the reproducibility test discussed in Section C.IV.3.c)dd). In this approach it is determined whether a “machine skilled in the art” could solve the problem in the same way as the inventor. If so, the invention can be categorised as obvious and therefore not inventive.¹⁰⁰² Using a reference algorithm to assess inventiveness in patent applications that involve AI has potential but raises a number of questions. While a patent office can find or create a reference algorithm, the main problems with this approach are the datasets, given that AI thrives on datasets as necessary inputs for training algorithms.¹⁰⁰³

To operate, the “machine skilled in the art” should operate on the same dataset used by the patent applicant, which raises questions about the confidentiality of the data, its contribution to the invention, and the efficiency of the examination process. In such a context of patent examination, the procedural steps involved in selecting appropriate datasets for analysis would be a factor excluded from consideration. This exclusionary approach serves to enable the examiner to concentrate their evaluation specifically on the inventiveness aspect of the application.¹⁰⁰⁴ If the individual or entity seeking a patent were to reveal the AI datasets employed in their innovation during the evaluation process, it could potentially diminish the attractiveness of patent protection for AI-related inventions. This is particularly significant in cases involving datasets that are not publicly available and where their exclusivity enhances the dataset’s worth.¹⁰⁰⁵ The shared use of such datasets by both patent applicants and a machine skilled in the art has raised concerns regarding matters pertaining to confidentiality, the transparency of patent examination procedures, and overall efficiency within the system.¹⁰⁰⁶

Three possible solutions are using a different dataset as a normal means of experimentation, using data as part of the state-of-the-art, and creating a general-purpose dataset that can be used for all AI inventions in the industry.¹⁰⁰⁷

in relation to AI patented inventions’, recording at 19:54 minutes, available under https://e-courses.epo.org/pluginfile.php/23528/mod_resource/content/3/html/page124198.html.

¹⁰⁰² Hazel V J Moir, ‘An inventive step for the patent system?’ (2013) 35(3) *European Intellectual property Review* 126-127 (questioning the rigor of the current examination of inventive step).

¹⁰⁰³ Bertin Martens, ‘The Impact of Data Access Regimes on Artificial Intelligence and Machine Learning’ (Digital Economy Working Paper No. 2018-09, Joint Research Centre Technical Reports, 2018) <https://www.econstor.eu/bitstream/10419/202237/1/jrc-dewp201809.pdf>.

¹⁰⁰⁴ Guido Noto La Diega, Gabriele Cifrodelli and Artha Dermawan, ‘Sustainable Patent Governance of Artificial Intelligence: Recalibrating the European Patent System to Foster Innovation (SDG 9)’ in B Amani, C Ncube and M Rimmer (eds), *Elgar Companion on Intellectual Property and Sustainable Development Goals* (Edward Elgar 2023) 26-27, Noto La Diega, Guido and Cifrodelli, Gabriele and Dermawan, Artha, Sustainable Patent Governance of Artificial Intelligence: Recalibrating the European Patent System to Foster Innovation (SDG 9) (2023). in Bita Amani, Caroline Ncube, and Matthew Rimmer (eds), *Elgar Companion on Intellectual Property and Sustainable Development Goals* (Edward Elgar 2023), available at SSRN: <https://ssrn.com/abstract=4438062>.

¹⁰⁰⁵ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 94 et seq.

¹⁰⁰⁶ Guido Noto La Diega, Gabriele Cifrodelli and Artha Dermawan, ‘Sustainable Patent Governance of Artificial Intelligence: Recalibrating the European Patent System to Foster Innovation (SDG 9)’ in B Amani, C Ncube and M Rimmer (eds), *Elgar Companion on Intellectual Property and Sustainable Development Goals* (Edward Elgar 2023) 27-28.

¹⁰⁰⁷ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.

aa) Treating Different Datasets as Standard Experimental Tools

The first proposed solution by *Schellekens* involves the use of a different set of data as the normal means of experimentation.¹⁰⁰⁸ When the reference algorithm takes the place of the expert, the reference data can be the means of experimentation normally available to the expert, or in this case the machine. To compare the merits of different AIs, a specific dataset can be used as a starting point. To isolate the algorithm's contribution to the inventiveness, the reference algorithm should work with the same data as the applicant's AI. This approach helps to determine what the machine skilled in the art can do and what is beyond its capabilities, and hence, inventive. If an ordinary algorithm operating on a rich dataset comes up with inventive solutions, if the reference algorithm uses the same data as the inventor, it may seem as if the invention does not involve an inventive step, but this occurs only because the highly rich and valuable dataset is treated as if it belongs to the state-of-the-art. Thus, it is necessary to determine whether the inventiveness derives from the dataset. However, when most companies are working with non-public datasets, it can be a challenge to create a dataset that is a normal baseline dataset used in the industry. Experts in the field may be able to compile such a dataset, but it would have to become public to fulfil its function as a reference dataset.¹⁰⁰⁹

This approach would only work if the patent applicant is willing to make the dataset he used available for inspection. This could be in line with the approach of the European Commission that is trying to create an environment that encourages data sharing.¹⁰¹⁰ Still, sharing data may make patent protection less attractive, especially when non-public datasets contribute to their value. Although a confidential disclosure of the dataset to the patent examiner may help, this raises questions about the verifiability of the examiner's work in opposition procedures or in court. Using the same dataset to assess inventiveness with the help of a reference algorithm raises issues in terms of confidentiality, transparency of the patent examination, and efficiency.

Still, this approach may be inefficient or impossible if each technical problem in an industry requires a customised dataset.¹⁰¹¹ Patent offices are looking at AI to make their examination processes more efficient, and checking whether inventiveness derives from the algorithm and subsequently from the dataset may not be very efficient. The use of the same dataset as the patent applicant raises questions about the specialization and contribution of the data to the outcome, and patent law does not differentiate between inventiveness due to the algorithm or the dataset.

bb) Considering Data as Part of the State of the Art

The second proposed solution by *Schellekens* is to use data as part of the prior art. According to Article 54(2) EPC, prior art includes everything that has been made available to the public

¹⁰⁰⁸ Ibid, 94.

¹⁰⁰⁹ Ibid.

¹⁰¹⁰ European Commission, 'A European Strategy for Data' (2020) <https://digital-strategy.ec.europa.eu/en/policies/strategy-data>.

¹⁰¹¹ See for example "AI on Data Tool" in EPO, 'Artificial Intelligence' <https://www.epo.org/en/news-events/in-focus/ict/artificial-intelligence>.

before the date of filing of the European patent application.¹⁰¹² Patient data can be, for example, part of the prior art, even if it requires a thorough analysis that a person skilled in the art may not have.¹⁰¹³ With a machine skilled in the art, the analysis is less onerous, and it can be assumed that the machine has access to everything in the relevant state of the art and can analyse it in a timely manner.¹⁰¹⁴

With this approach, the reference dataset would consist of the most relevant data that is publicly available, avoiding difficulties with confidential or secret data. The creation of a large dataset may raise the bar for inventiveness, depending on which data proves to be the most relevant, whether public or private. The question of how to compose a reference dataset for assessing the inventive step in AI inventions remains a difficult one, posing the question if such a machine or skilled person would have access to all the data it incorporates and by means of its calculating capacity, the entire state of the prior art and all its possible correlations, even in unrelated scientific fields.¹⁰¹⁵ This poses the question if, at some point, everything will be obvious and therefore not inventive.¹⁰¹⁶

While using one general dataset for an industry could result in high efficiency, it may also lead to a low standard for the inventive step if inventors tailor their datasets to their specific problems. Alternatively, creating a reference dataset for each invention from public data would likely be too inefficient and result in lengthy debates about inclusion criteria. Including all public data in the dataset may lead to an unacceptably long calculation time. One possible solution could be to use a hybrid approach that combines industry-specific datasets. For instance, patent offices could develop a set of general datasets for each industry that cover common technical problems. When assessing an AI-related invention, patent examiners could start with these general datasets and then supplement them with datasets that the applicant provides. This approach could strike a balance between efficiency and accuracy, while also taking into account the unique features of each invention. Another possibility is to develop a framework that considers not only the dataset but also the algorithm itself. In this case, the reference dataset could be used as a baseline to assess the performance of the algorithm. For instance, if an AI-related invention achieves a higher accuracy rate than the reference algorithm on the same dataset, it could be considered inventive. This approach could help address concerns about the dataset's contribution to the invention while also accounting for the algorithm's performance.

¹⁰¹² Maurice Schellekens, 'Artificial Intelligence and the re-imagination of inventive step' (2022) 13(2) *JIPITEC* 95.

¹⁰¹³ EPO, T 2101/12, 24 January 2018 (*Authentication binding document with signature/VASCO*) § 6.5-6.8.

¹⁰¹⁴ EPO, T 426/88, 9 November 1990 (*Combustion engine*), § 6.1.

¹⁰¹⁵ Daniele Fabris, 'From the PHOSITA to the MOSITA: Will "Secondary Considerations" Save Pharmaceutical Patents from Artificial Intelligence?' (2020) *IIC* 692, where it is stated that the sector expert (so-called PHOSITA) should soon be replaced by a sector expert machine (so-called MOSITA), which knows all existing prior art and all their possible correlations. See also: Stefan Luginbühl, 'Patent Protection of Inventions Involving Artificial Intelligence' in *Transition and Coherence in Intellectual Property Law: Essays in Honour of Annette Kur* (Cambridge University Press, Cambridge 2021) 196 et seq., where the author questions whether inventive step will be abolished once AI is able to create inventions independently and the machine becomes the standard for an expert in the field.

¹⁰¹⁶ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 31; Michael McLaughlin, 'Computer-Generated Inventions' (2019) 101 *Journal of the Patent and Trademark Office Society* 224; Tabrez Y Ebrahim, 'Data-Centric Technologies: Patent and Copyright Doctrinal Disruptions' (2019) 43 *Nova Law Review* 309 (discussing the impact of technologies on the non-obviousness of inventions).

cc) Creating a General-Purpose Dataset for AI Inventions

The third proposed solution by *Schellekens* is to create a general dataset that can be used for all AI inventions in the industry.¹⁰¹⁷ Such a dataset, which would be a normal means of experimentation, could be assembled and maintained by the EPO or by an external provider with the help of experts in the field. This dataset would need to become public to fulfil its function as a reference dataset and the EPO could provide the machine skilled in the art access to the datasets.¹⁰¹⁸

Although a “machine skilled in the art” approach does not seem fitting given that persons still play a crucial role in the inventive process, the three approaches discussed offer pathways to enhance patent examination efficiency. Importantly, these approaches can be effectively combined with the “Skilled Person 2.0” model described in Section D.V.3., further refining the evaluation of inventiveness in AI-related inventions.

d) The EPO’s Cautious Approach in T 1193/23

Recently in T 1193/23 the EPO BoA addressed whether LLMs, can be relied upon for interpreting technical terms in patent claims.¹⁰¹⁹ At issue was whether LLMs-generated responses could serve as evidence of how a person skilled in the art would understand a term like “bearing regulation” in the context of a patent claim.¹⁰²⁰ The Board concluded that while LLMs may assist, they cannot substitute expert analysis or technical literature and do not themselves qualify as person skilled in the art under European patent law. Although not entirely dismissing LLMs evidence, the Board stressed that such outputs must be substantiated, for example, by citing technical literature.¹⁰²¹

The dispute involved EP 3118356, owned by Rieter, concerning safety systems in rotor spinning machines. The patent’s validity hinged on whether the term “bearing regulation” in the claim had a narrower meaning than proposed by the opponent, Saurer Spinning Solutions GmbH.¹⁰²² During oral proceedings, the patentee cited ChatGPT responses as support for a narrower claim interpretation. However, the Board found these responses irrelevant, noting that claim interpretation depends on the person skilled in the art’s understanding, which must be

¹⁰¹⁷ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 95.

¹⁰¹⁸ Guido Noto La Diega, Gabriele Cifrodelli and Artha Dermawan, ‘Sustainable Patent Governance of Artificial Intelligence: Recalibrating the European Patent System to Foster Innovation (SDG 9)’ in B Amani, C Ncube, and M Rimmer (eds), *Elgar Companion on Intellectual Property and Sustainable Development Goals* (Edward Elgar 2023) 28.

¹⁰¹⁹ EPO, T 1193/23, 14 April 2025.

¹⁰²⁰ Rose Hughes, ‘An LLM is not (yet) a person skilled in the art (T 1193/23)’ (IPKat, 19 May 2025) https://ipkitten.blogspot.com/2025/05/an-llm-is-not-yet-person-skilled-in-art.html?utm_source=chatgpt.com.

¹⁰²¹ Ibid.

¹⁰²² Ibid.

supported by expert evidence or authoritative sources.¹⁰²³ The ChatGPT output, without such evidence, lacked evidentiary weight.

That LLMs and AI-based chatbots are now widely used does not, by itself, support the assumption that their responses accurately capture the view of the skilled person within the relevant field at the relevant moment.¹⁰²⁴ The responses generated by a chatbot are derived from training data that is not disclosed to the user and may vary significantly depending on the context and the precise wording of the prompt. Moreover, as noted in T 206/22, the interpretative output of a chatbot is, in principle, derived from the entirety of information accessible to it, which may include sources published after the effective date of the claim.¹⁰²⁵ Consequently, such an interpretation does not necessarily align with the understanding that a skilled person would have had at the relevant priority date.¹⁰²⁶ When relying on internet-based sources as prior art, it must be demonstrated that the content was publicly available before the effective date of the claim. This requirement cannot currently be fulfilled in relation to data generated by chatbots, as there is no existing mechanism, such as a “wayback machine”, to verify the temporal availability of chatbot outputs.¹⁰²⁷

Thus, the Board highlighted three key limitations of LLMs in this context. The first limitation is unknown training data, making it difficult to assess alignment with common general knowledge. Still, it can be argued that this objection may be overly cautious, as many LLMs are trained on sources likely to include common general knowledge. The second limitation is context-sensitive outputs, which may vary with prompt formulation, and the third is a lack of expert-level validation, particularly at the relevant historical date. While these last objections are more persuasive, they could be mitigated by carefully crafted prompts situating the LLMs in the correct technical field and legal framework.¹⁰²⁸

T 1193/23 sets a precedent: while LLMs are not equivalent to a person skilled in the art and cannot serve as sole evidence in patent interpretation, their outputs may be used if accompanied by appropriate supporting documentation. Going forward, the effective use of LLMs in patent law will depend on how well they are contextualised and documented. Their potential lies in augmenting, not replacing, human expertise in interpreting technical language.

e) Tentative Findings

Overall, the assessment of the inventive step in AI-related inventions raises difficult questions regarding both the algorithm and data selection. While current literature tends to focus on the

¹⁰²³ In this context, the BoA referred to EPO, T 206/22, 15 March 2024, § 1; see also: Daniel X Thomas, ‘T 1193/23 – A chatbot does not replace the skilled person’ (IPappify Blog, 19 May 2025) <https://blog.ipappify.de/63310-2/>.

¹⁰²⁴ Daniel X Thomas, ‘T 1193/23 – A chatbot does not replace the skilled person’ (IPappify Blog, 19 May 2025) <https://blog.ipappify.de/63310-2/>.

¹⁰²⁵ EPO, T 206/22, 15 March 2024, § 1.

¹⁰²⁶ Ibid.

¹⁰²⁷ Ibid.

¹⁰²⁸ Ibid.

algorithm, the data used by the algorithm is just as crucial and may raise privacy, competition, feasibility and efficiency concerns.¹⁰²⁹

Assessing the inventive step through a reference algorithm is also challenging. The adaptation of the algorithm to each new problem may make it difficult to develop a general reference algorithm that sets the bar for the inventive step at an appropriate level. If a general algorithm is not tailored to a specific problem, it may set the bar too low. If a tailored algorithm replicates the invention, it may indicate obviousness rather than inventiveness. At the same time companies may choose to keep information-rich datasets private to gain a strategic advantage in competition and patenting, making it difficult to create a general-purpose dataset.

Although very futuristic, the “machine skilled in the art” approach has been criticised by various players in the field, especially considering the current capabilities of inventive AI.¹⁰³⁰ The notion of “machine skilled in the art” is linked to the belief that AI is capable of independent inventions: if an inventive AI replaces the human inventor, then a machine/AI can replace the “human” person skilled in the art.¹⁰³¹ Until that point these approaches seem farfetched. Although the analysis of patents has hardly changed in the last 50 years, experience shows that in the long run machines outdo humans in almost every aspect of life. It remains unclear whether an AI system could ever fully replicate the capabilities and knowledge of a human inventor and then the one of a human skilled in the art.¹⁰³²

3. Proposal of a “Skilled Person 2.0”: A Hybrid Concept

Although the notion of considering the average specialist solely as an AI system, a “machine skilled in the art”, seems technically and legally flawed, as AI continues to develop and its role in the innovation process becomes increasingly significant, there seems to be the need to redefine who the person skilled in the art is.¹⁰³³ Potentially, the person skilled in the art would

¹⁰²⁹ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 2 et seq.

¹⁰³⁰ Joseph Straus, ‘Will Artificial Intelligence Change Some Patent Law Paradigms?’ (2021) 81 *Zbornik Znanstvenih Razprav* 45 (recalling that in the summary of the USPTO’s response to the consultation, it is stated that “according to the majority of public commenters, the current state of the art is limited to ‘narrow’ AI, and AGI has not yet arrived”. Moreover, that the “current AI could neither invent nor author without human intervention”, and “that human beings remain integral to the operation of AI”. Finally, that the existing “US intellectual property laws are calibrated correctly to address the evolution of AI”. See also: USPTO, ‘Public Views on Artificial Intelligence and Intellectual Property Policy’ (October 2020) ii-iii.

¹⁰³¹ Ibid, 26; see also: Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 502 (the author wonders whether the legislator should consider broadening the concept of a person skilled in the art to also include “thinking machines”).

¹⁰³² Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 26; Liza Vertinsky, ‘Thinking Machines and Patent Law’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 502.

¹⁰³³ Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1122 et seq.; Erica Fraser, ‘Computers as Inventors - Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 320 et seq.; Tim W Dornis, ‘Artificial Intelligence and Innovation: The End of Patent Law as We Know It’ (2020) 23 *Yale Journal of Law & Technology* 125 et seq. (stating that the use of AI to support human inventiveness implies groundbreaking changes for the concept of the PHOSITA); Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law’ (2018) 39 *Cardozo Law Review* 2216 et seq.

need to be equipped with AI systems and be able to program them to perform specific tasks, to keep up with the increasing use of AI in research and development. Its identity and capabilities may need to evolve as AI becomes more prevalent.¹⁰³⁴ This also applies to discerning what qualifies as routine technological progress and what is not obvious to the hypothetical skilled person based on the current state of knowledge.¹⁰³⁵

This subchapter introduces the notion of a “Skilled Person 2.0” as a heuristic device to reflect the evolution of the person skilled in the art in light of widespread integration of AI in inventive processes. While it may be contended that current patent law already accommodates the evolution of the skilled person’s capabilities, including the use of standard AI tools or interdisciplinary collaboration, this concept seeks to make the adaptation explicit and systematic. The label “2.0” is not intended to denote a wholly new legal category but to articulate more transparently that, in fields where AI tools have become standard practice, the skilled person must be presumed to possess routine access to and competence in these technologies. This position aligns with the established understanding that the skilled person holds the ordinary means and capacities of the field, as recognised by the EPO.

Although the skilled person may already be conceptualised as a team in complex disciplines, the proposal highlights that the increasing role of AI necessitates a rethinking of how this legal fiction encompasses new epistemic tools. The skilled person may thus be construed as an individual routinely working with standard AI tools or as a composite team including AI specialists. This reconceptualization ensures the evaluation of inventive step reflects actual research and development practices and provides clarity in the treatment of AI-assisted inventions.

a) Definition

The “Skilled Person 2.0” would be constructed as a hybrid person that includes knowledge, skills, and means related to AI, or as a team of experts that includes an AI specialist.¹⁰³⁶ Under the new “Skilled Person 2.0” model a modification of the person skilled in the art to “a skilled person using an ordinary AI tool in the art” is proposed.¹⁰³⁷

The “Skilled Person 2.0” would have a level of expertise that considers the use of AI in the relevant technical field, meaning that the “Skilled Person 2.0” would have a higher level of expertise than the current person skilled in the art, to ensure that they are able to use AI technology effectively in the inventive process. This approach envisions the skilled person as an individual who has access to, and proficiency in, AI tools and techniques widely available

¹⁰³⁴ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866.

¹⁰³⁵ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 6.

¹⁰³⁶ Tim W Dornis, ‘Artificial Intelligence and Innovation: The End of Patent Law as We Know It’ (2020) 23 *Yale Journal of Law & Technology* 127; Tim W Dornis, ‘Künstliche Intelligenz und Innovation – Perspektiven der Disruption im Patentrecht (Teil 1)’ (2020) *Mitteilungen der deutschen Patentanwälte* 442.

¹⁰³⁷ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 11.

in the relevant field.¹⁰³⁸ This ensures that the skilled person can use all the resources in the field, including AI tools. In some cases, an interdisciplinary team, comprising an AI practitioner and a data scientist, might represent the skilled person, considering AI's broad applicability as a "general-purpose" technology across various fields.¹⁰³⁹ This could help to ensure that patent applications from AI-related inventors are assessed by individuals who possess the necessary expertise to evaluate their technical subject matter and assess their inventiveness. Similar to how an ordinary person skilled in the art refers to an artisan who is not capable of making significant creative leaps, the ordinary AI tool is defined as a routine AI system that cannot independently create or generate new inventions and has already been disclosed by prior art.

This revised standard envisions a person equipped with an AI system to evaluate pending AI patent applications in a fair, timely, and efficient manner. Even when confronted with unprecedented challenges, a skilled person utilizing an ordinary AI system can swiftly comprehend the most recent information and be well-prepared to assess the inventive step.¹⁰⁴⁰

The "Skilled Person 2.0" model posits that the skilled person operates with routine, general-purpose AI tools, those not themselves inventive and whose functioning is disclosed in the prior art. This approach aligns the assessment of inventive step with contemporary realities, much as prior generations incorporated databases or microscopes into the skilled person's capabilities. Yet, this reframing presents challenges for assessing non-obviousness, particularly in scenarios where AI produces outputs that are unforeseen or emergent.

b) The Means, Capacities and Knowledge of the "Skilled Person 2.0"

Before evaluating whether a given invention is obvious to a skilled person using AI tools, it is necessary to determine whether such tools constitute part of the typical means and knowledge in the relevant field.¹⁰⁴¹

aa) The Means and Capacities

As previously discussed, under EPO practice, the skilled person is deemed to have access to the "means and capacity for routine work and experimentation typical for the field".¹⁰⁴²

Consequently, AI should be regarded as part of the skilled person's resources only if it constitutes a routine tool for standard work and experimentation within that field at the relevant

¹⁰³⁸ Uwe Fitzner and Alex Metzger, 'PatG § 3', in U Fitzner, S Kubis und T Bodewig, *Beck'scher Online-Kommentar Patentrecht* (Munich 2023) para 8; Sven Sabellek, *Patente auf nanotechnologische Erfindungen* (Carl Heymanns, Cologne 2014) 52 et seq.

¹⁰³⁹ Josef Drexler et al., 'Position Statement on IP Law and Artificial Intelligence' (MPI Research Paper No. 21-10, 9 April 2021) 24 et seq.

¹⁰⁴⁰ Ibid.

¹⁰⁴¹ Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 228.

¹⁰⁴² EPO Guidelines 2025, Part G-VII, 3.

time.¹⁰⁴³ If AI is a “normal” tool in the relevant technical field, the capabilities of the skilled person are correspondingly enhanced.¹⁰⁴⁴ An invention would thus be patentable only if the proposed solution would not have been obvious to a skilled person using AI tools, regardless of whether the inventor used AI tools.¹⁰⁴⁵

This adaptation could draw parallels from other scenarios where the hypothetical skilled practitioner employs conventional tools, such as electronic data processing, microscopy, or the use of laboratory equipment.¹⁰⁴⁶ The same logic may be extended to LLMs, such as ChatGPT-4o, insofar as they have become ubiquitously available and are regularly used across technical fields. More so than traditional means, common LLMs can be applied to all technical fields. By 2025, tools like ChatGPT-4o had achieved a level of accessibility, reliability, and general applicability comparable to that of conventional digital tools such as Google Search. In light of this, it becomes increasingly reasonable to presume that the skilled person would be proficient in the use of such systems, regardless of the specific technical field in question.

This presumption does not imply that the skilled person adopts every novel or experimental application of generative AI. However, where such tools are used in a standardised, well-understood, and non-experimental manner, their use may be considered part of the skilled person’s routine practice.

The implication of this expanded toolkit is twofold. First, it broadens the informational resources accessible to the “Skilled Person 2.0”, who may now be assumed capable of retrieving, summarising, and synthesising complex technical data using conversational AI systems. Second, it extends the cognitive capacities of the skilled person, allowing for improved problem-solving strategies, particularly where LLMs are employed as reasoning aids or drafting assistants, rather than as sources of original inventive content.

Still, this does not imply that the “Skilled Person 2.0” becomes omniscient or indistinguishable from the AI system itself. The legal fiction remains anchored in human cognition and domain-specific expertise, therefore the AI per se is not the person skilled in the art. Only the insights

¹⁰⁴³ EPO, ‘Comments by the European Patent Office, WIPO Conversation on Intellectual Property (IP) Artificial Intelligence (AI), Second Session July 7 to 9, 2020, Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence’ (WIPO/IP/AI/2/GE/20/1 REV) 7 (stating that “if AI is used in the relevant field of technology, it will be used by the skilled person and their skill will raise accordingly”). See also: Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866 et seq.; Mario Libertini, ‘I prodotti inventivi dell’intelligenza artificiale’ (Academia, 2021) https://www.academia.edu/72692969/I_prodotti_inventivi_dellintelligenza_artificiale (reluctantly allowing that this is perhaps the best available solution, but that it likely generates excessive complexities); Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 25 et seq.; Matt Hervey, Virginia Driver and Tom Woodhouse, ‘Intellectual Property’ in M Hervey and M Lavy (eds), *The Law of Artificial Intelligence* (Sweet & Maxwell 2020) § 8-093; Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 109-110; Joel S H Nägerl, Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 338.

¹⁰⁴⁴ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 112-114.

¹⁰⁴⁵ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 230.

¹⁰⁴⁶ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 866 et seq.

derivable through standard application of common AI tools, as ChatGPT-4o, are attributed to the skilled person. The use of AI/LLMs must still be limited to applications that reflect common general knowledge. The tools must be used in a manner consistent with prevailing professional norms, without requiring further inventive insight or experimentation. Outputs generated through individual prompts, complex configurations, or context-dependent uses that exceed routine understanding should not be attributed as obvious for the skilled person. In this way, the inclusion into the mental apparatus of the skilled person of AI tools that are more sector specific must remain conditional upon their integration into the accepted technical practices of the field.

bb) The Knowledge

When it comes to the knowledge of the “Skilled Person 2.0”, it must be considered how the use of AI impacts on the knowledge of the person skilled in the art.¹⁰⁴⁷

The first group would be knowledge of generally applicable AI-systems, accessible widely as for example ChatGPT-4o in 2025. The assessment would not need to take into consideration the use of AI in the specific sector(s) of the invention. Such systems are universally accessible, commonly used, non-experimental and widely accepted across domains, it is increasingly appropriate to treat them as part of the skilled person’s standard repertoire. This reflects a broader evolution in how tools are integrated into the knowledge base of the skilled person, paralleling previous shifts such as the widespread adoption of electronic databases or search engines.

The second group would be knowledge of specific AI tools with specific datasets that must be discussed in standard reference works or widely adopted in industrial practice, for their inclusion to be justified.¹⁰⁴⁸ Thus, to define the skilled person in a field where AI-related inventions may be prevalent, one must first determine if standard reference literature (for example, textbooks and encyclopaedias) indicates the use of specific AI as a research tool in that field. If not, one should examine more specialized sources like research papers and patents, as well as unconventional sources such as YouTube tutorials, if justified in that field.¹⁰⁴⁹ The essence of determining common general knowledge lies not in the source of the information itself, but in whether the information is “commonly accepted” in the field and can be used “without doubts or further research work” by the skilled person. As long as the use of AI tools remains experimental, requires significant expertise, or is fraught with uncertainties (for example, regarding its configuration and utility), it will not be part of the common general

¹⁰⁴⁷ Peter R Slowinski, ‘Artificial Intelligence, Novelty and Inventive Step: What Is the Impact of AI on Patent Law?’ in Z Sikorski and J Zemła-Pacud (eds), *Patents as an Incentive for Innovation* (Wolters Kluwer, Alphen aan den Rijn 2021) 263.

¹⁰⁴⁸ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 232.

¹⁰⁴⁹ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 428 et seq.

knowledge.¹⁰⁵⁰ Thus the integration of specific AI tools into the skilled person's knowledge base hinges on whether these tools fall within the domain of common general knowledge.¹⁰⁵¹

The skilled person would be required to have knowledge relevant to the use of AI in that sector if AI is part of the state of the art. In the same way, one could also imagine that, again in the case of a field in which AI is used, the team constituting the expert must also have among its members an AI specialist or a computer scientist with average knowledge and skills in AI techniques.¹⁰⁵² Since AI is more efficient at searching for solutions, fields that might not have been considered previously could now be explored. This means that the threshold for what is considered a potential source for a solution may be lower than before. As a result, the criteria for determining what constitutes an inventive step may need to be adjusted. This is a natural development in a situation where AI makes the process of inventing easier.¹⁰⁵³

Moreover, it is essential to recognise that an AI system possesses the capability to process extensive data, potentially expanding the domain from which existing knowledge is drawn. This expansion is similar to the concept of an interdisciplinary team, though on a much larger scale.¹⁰⁵⁴ However, limitations remain likely: It would be an overstatement to assume that an AI system inherently incorporates the entire available knowledge across all disciplines, much like the introduction of the internet did not result in the hypothetical expert absorbing all available knowledge to the same degree.¹⁰⁵⁵ A pivotal factor will centre around whether the average AI system would have deduced the solution from the teachings if employed by the skilled practitioner for its intended purpose.¹⁰⁵⁶

¹⁰⁵⁰ Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 159-160; Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 231.

¹⁰⁵¹ Noam Shemtov and Garry Gabison, 'The Inventive Step Requirement and the Rise of the AI Machines' in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 432 et seq.; in the US scholarship, see William Samore, 'Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?' in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018) 483, who proposes a four-factor test to determine whether AI tools (and specifically genetic programming) should be framed as part of the skilled person, namely: (a) whether the invention was actually designed by AI; (b) the proportions of skilled person in the field having access to AI; (c) the cost associated with the use of AI; (d) the amount of time and effort required to operate AI.

¹⁰⁵² Olga Gurgula, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 17 et seq.

¹⁰⁵³ Maurice Schellekens, 'Artificial Intelligence and the re-imagination of inventive step' (2022) 13(2) *JIPITEC* 89 et seq.

¹⁰⁵⁴ Christian Heinze and Andreas Engel, 'KI und Patentrecht' in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 63; Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, 'Künstliche Intelligenz: Paradigmenwechsel im Patentsystem' (2019) *GRUR* 338; Yann Ménière and Heli Pihlajamaa, 'Künstliche Intelligenz in der Praxis des EPA' (2019) *GRUR* 334.

¹⁰⁵⁵ Fédération Internationale des Conseils en Propriété Intellectuelle, 'Response to USPTO Request for Comments on Patenting Artificial Intelligence Inventions' (8 November 2019) 5 https://www.uspto.gov/sites/default/files/documents/FICPI_RFC-84-FR-44889.pdf.

¹⁰⁵⁶ The test proposed by Abbott appears to focus solely on this question (Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 41).

cc) Evaluating Obviousness

Obviousness depends on whether the skilled person, equipped with standard AI tools and accessible datasets, would arrive at the invention without inventive ingenuity. The relevant test is whether such an outcome follows predictably from the known prior art. To facilitate this, one may adopt the construct of a “reference AI” for each year, a general-purpose model configured using publicly available data and standard parameters. If such a system, in the hands of the skilled person, would reliably produce the invention, then it may lack inventive step.

As *Jacob LJ* observed, combining skills from different fields to solve a problem may be either obvious or non-obvious. In these situations, a traditional inventive step analysis is used. According to the EPO’s approach, if the closest prior art suggests using an AI tool to solve the problem and this leads to the solution, the invention might lack an inventive step.¹⁰⁵⁷ However, if the skilled person is not familiar with a AI, combining different fields’ prior art might not be obvious. Even if they considered using an AI tool, the extra steps needed might make it less likely to find an inventive step. Moreover, for computational tools, it is assumed that with enough time, the invention could have been achieved.¹⁰⁵⁸

If AI is a “normal” tool in a particular technical field, the inventive step is generally assessed based on what a skilled person using AI tools would achieve.¹⁰⁵⁹ However, this does not automatically mean that everything will be obvious to such a skilled person, contrary to some opinions.¹⁰⁶⁰ The evaluation must be tailored to the specific facts of each case. As pointed out by *Shemtov* and *Gabison*, patent examiners need to determine if the skilled person, using AI tools and knowledge in a routine manner, would find the invention obvious.¹⁰⁶¹ Just possessing AI skills and tools does not ensure that applying them will lead to the invention. For instance, even if certain AI tools are standard in a field, a human inventor might still exceed the capabilities of an AI-enabled skilled person.¹⁰⁶² The inventor might have created a unique AI system specifically designed to address the objective technical problem more effectively than conventional tools. If the invention depends on using this specialized tool and its use is not obvious, it can still be considered inventive.¹⁰⁶³

¹⁰⁵⁷ Ibid.

¹⁰⁵⁸ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 251-253.

¹⁰⁵⁹ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 117.

¹⁰⁶⁰ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 31 et seq.; Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 691 et seq.

¹⁰⁶¹ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 432; Olga Gurgula, ‘AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis’ (2020) 2(8) *International Journal of Social Science and Public Policy* 19-20.

¹⁰⁶² Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 71.

¹⁰⁶³ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 432; Cesare Galli and Mariangela Boggi, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 132; Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 71; Joel Nägerl,

Furthermore, employing a “normal” AI tool in an unconventional way, such as with unconventional or synthetic data, could also be non-obvious.¹⁰⁶⁴ These possibilities, including human advantage, enhanced bespoke tools, and novel uses, might be combined and further explored.¹⁰⁶⁵ If the invention arises from non-routine elements such as proprietary data, novel problem formulations, or unique configurations, it may still involve an inventive step. The *Halicin* case illustrates this: although AI was used, the ingenuity resided in the application of the model and the design of the training dataset. Hence, inventiveness may lie not in using AI per se, but in the original human contribution in shaping or applying it. If a specific AI is not a typical tool for the skilled person, the inventive step might lie in choosing to apply an AI method to solve a problem.¹⁰⁶⁶ In such cases, the key questions would be whether it was obvious for the “Skilled Person 2.0” to consult AI-related prior art or seek AI expertise and, if they did, whether the solution would have been straightforward.

A critical distinction must therefore be made between routine and innovative use of AI. Although the “Skilled Person 2.0” would be expected to use general AI models and, if applicable to the technical field also specific AI systems, the skilled person is not expected to reproduce outcomes involving data curation or parameter adjustments that fall outside ordinary practice.

c) Challenges in the Assessment

As seen in the previous section, the “Skilled Person 2.0” presents several challenges.

aa) Changing Tools

The evolving nature of AI presents a challenge. Once an AI tool becomes standard, any result it routinely produces may appear obvious, thereby narrowing the space for patentable subject matter. This risk requires careful calibration.

This assessment is likely to face particular difficulties in cases where a single AI system is used within a specific technical field and is regarded as part of the skilled person’s standard toolkit. In such scenarios, the AI system effectively functions as the instrument through which the skilled person operates. However, this framing raises a critical concern: if any invention produced using that AI system must still meet the threshold of non-obviousness, it could imply that only those outputs which exceed what the AI system is expected to deliver would be patentable. This, in turn, creates a risk that inventions generated through such AI systems might

Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 338 et seq.

¹⁰⁶⁴ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R. Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 432; Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 338 et seq.

¹⁰⁶⁵ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 253-255.

¹⁰⁶⁶ Matt Hervey, Virginia Driver and Tom Woodhouse, ‘Intellectual Property’ in M Hervey and M Lavy (eds), *The Law of Artificial Intelligence* (Sweet & Maxwell 2020) § 8-090.

be presumed to lack inventiveness simply because the system itself is considered part of common general knowledge.¹⁰⁶⁷

More complex scenarios arise when multiple AI systems are employed within a field.¹⁰⁶⁸ Selecting one specific AI system as the practitioner's choice would reiterate the problem observed with a singular AI in the field, potentially making the attainment of non-obvious outcomes more challenging. This leads to considering the premise that the practitioner utilises multiple AI systems. Consequently, the question arises whether an inventive step is established if the outcome would not have been obvious even with the use of one of these systems.¹⁰⁶⁹ If multiple AI tools exist and none would predictably yield the invention, then an inventive step may still be recognised. The key question is not just the presence of AI tools in the field, but their capacity to produce the claimed invention under normal use.

The tools available to the skilled person would change according to the progressive use of AI in certain fields. The timing of when an AI tool becomes "standard" is crucial, both for general and specific AI systems. In the moment AI becomes a routine tool in the hands of the expert, like a microscope for a microbiologist, AI becomes a means at disposal of the skilled person.¹⁰⁷⁰ It will be a challenge for patent offices to decide the exact moment when AI becomes can be considered a routine tool in the research and development activity of a specific sector¹⁰⁷¹ and thus it becomes part of the expert's toolbox.¹⁰⁷² Patent applications can actually be of help. According to Article 83 EPC, the application must illustrate the invention clearly and completely enough for the expert in the field to repeat it without excessive burdens,¹⁰⁷³ without including the process that led to the invention.¹⁰⁷⁴ A human is not likely to detach that an invention is simply the result of massive computational power and trial and error searching: the results would seem astonishing for humans, but rather obvious for AI.

¹⁰⁶⁷ Tim W Dornis, 'Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 1)' (2020) *Mitteilungen der deutschen Patentanwälte* 436 et seq.

¹⁰⁶⁸ Andreas Engel, 'Erfinderische Tätigkeit und Künstliche Intelligenz' (2022) *GRUR* 864 et seq.

¹⁰⁶⁹ Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 40.

¹⁰⁷⁰ While tools usually start out 'special', as there are few of them or a complex prototype not yet destined and ready for mass production, they become 'standard' the moment there is a mould, model, or the like. For a definition see: 'Standard tool' (Law Insider) <https://www.lawinsider.com/dictionary/standard-tool>.

¹⁰⁷¹ Such a discussion can be found in the case law of EPO where the relevance of everyday objects from a technical field other than that of the invention under analysis is discussed (see for example: EPO, T 1043/98, 11 May 2000).

¹⁰⁷² Daniel Gervais, 'Exploring the Interfaces Between Big Data and Intellectual Property Law' (2019) 10 *Journal of Intellectual Property, Information Technology and Electronic Commerce Law* 25 et seq.; Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für geistiges Eigentum* 389 et seq.; Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, 'Künstliche Intelligenz: Paradigmenwechsel im Patentsystem' (2019) *GRUR* 336 et seq.; Iain M Cockburn, Rebecca Henderson and Scott Stern, 'The Impact of Artificial Intelligence on Innovation' (2018) NBER Working Paper No 24449 <http://www.nber.org/papers/w24449> (the authors point to AI as a general-purpose technology that can be used in all sectors).

¹⁰⁷³ EPO, T 32/85, 5 June 1986, § 5.

¹⁰⁷⁴ This approach reflects the well-established principle that the manner in which the invention was actually achieved is irrelevant to the finding of inventive step, which requires an assessment of an objective nature. In this regard, see Noam Shemtov, 'A study on inventorship in inventions involving AI activity' (Commissioned by the EPO, February 2019) 35; Anne Lauber-Rönsberg and Sven Hetmank, 'The Concept of Authorship and Inventorship Under Pressure: Does Artificial Intelligence Shift Paradigms?' (2019) 14(7) *JIPLP* 571 et seq.; Stefan Luginbühl, 'Patent Protection of Inventions Involving Artificial Intelligence' in *Transition and Coherence in Intellectual Property Law: Essays in Honour of Annette Kur* (Cambridge University Press, Cambridge 2021) 196 et seq.

This reinforces the need to distinguish between outcomes that appear surprising to humans versus those that are technically inevitable given the tools and data available. Legal analysis must resist the temptation to conflate “human surprise” with non-obviousness.

bb) Appropriate AI Version and Datasets

Once a tool is deemed routine, it remains to determine which version of the tool and which data inputs are attributed to the “Skilled Person 2.0”.¹⁰⁷⁵ This can be difficult since the learning process itself and the data the AI was fed makes the machine.¹⁰⁷⁶

To develop an AI, the researcher feeds information into a computer system, which then learns through a probabilistic approach, identifying new patterns based on the learned patterns. The learning that the machine goes through makes the machine.¹⁰⁷⁷ Without the “right” type of data, AI expertise and techniques are of little use to the AI-skilled person. In fact, an AI tool may be inadequate without the suitable data for training this AI system and optimizing it for addressing the problem that the invention seeks to tackle.

The reference AI must therefore be understood as one configured with publicly available data and default settings. If the claimed invention relies on proprietary data or innovative data selection, it cannot be assumed to fall within the reach of the skilled person. The *Halicin* case again demonstrates that the originality may lie in dataset construction rather than algorithmic implementation. Researchers assembled a training dataset of over 2.000 molecular structures, labelled as either hit or non-hit against *E. coli*.¹⁰⁷⁸ This molecular data was then converted into linear vectors for processing. The deep learning model was trained on this processed dataset to predict the properties of a new effective antibiotic. After training, the model was provided with an input dataset of over 6.000 molecules, which led to the identification of the first successful hits. In both instances, the molecular information was obtained from publicly accessible databases, though the research team made deliberate selections within those datasets.¹⁰⁷⁹

The *Halicin* research approach illustrates several factors that must be considered. These include the selection of training and input data (both in terms of source and specific data points), the method of processing/conversion of that data, and the various rounds of training using the data.¹⁰⁸⁰ It is essential to recognize that the training and input data used by inventors may not always be publicly available; they might be internal proprietary information (or trade secrets) of a company or protected by data privacy regulations. An example of inaccessible data is

¹⁰⁷⁵ EPO, Case Law of the BoA 2022, I-D.,8.1.1.

¹⁰⁷⁶ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ (2022) *Queen Mary Law Research Paper No. 375/2022* 15.

¹⁰⁷⁷ Zoubin Ghahramani, ‘Probabilistic Machine Learning and Artificial Intelligence’ (2015) 521(7553) *Nature* 452-459.

¹⁰⁷⁸ Jonathan M Stokes et al., ‘A Deep Learning Approach to Antibiotic Discovery’ (2020) 180 *Cell* 690.

¹⁰⁷⁹ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 237.

¹⁰⁸⁰ Matt Hervey, Virginia Driver and Tom Woodhouse, ‘Intellectual Property’ in M Hervey and M Lavy (eds), *The Law of Artificial Intelligence* (Sweet & Maxwell 2020) § 8-094.

clinical trial data held by pharmaceutical companies.¹⁰⁸¹ Therefore, even if a particular type of machine learning model and its settings are regarded as “normal” in the field and part of the common general knowledge, this alone does not ensure that an average skilled person would have routine access to these machine learning techniques, nor does it imply a reasonable expectation of success.¹⁰⁸² Evaluating whether the current state of affairs sufficiently promotes innovation might require separate consideration and potentially legislative measures beyond the scope of patent law, such as those under the European Union’s open data initiatives.¹⁰⁸³

4. Preliminary Results

The integration of AI into the inventive process prompts a reconsideration of the traditional concept of the “person skilled in the art”, as AI significantly enhances inventors’ knowledge and problem-solving capabilities. The current person skilled in the art-standard may no longer reflect modern inventive practices, and incorporating AI into this legal fiction could help ensure that the non-obviousness requirement remains meaningful. However, doing so risks disadvantaging human inventors who do not rely on AI.

Several models have been proposed in response. *Abbott’s* “machine skilled in the art” model imagines a hypothetical AI trained in a specific field and capable of independently solving technical problems. It distinguishes between “skilled” and “inventive” AIs, though in practice this distinction is difficult to apply. Some have therefore proposed assessing inventiveness based on what is non-obvious to an “inventive” AI, a move that would raise the patentability threshold considerably. An alternative model defines the machine skilled in the art as a group of established AI systems and uses consensus among them to determine obviousness. While potentially robust, this approach faces legal and technical challenges, including how to interpret AI outputs and reconcile AI reasoning with human expertise. A third approach involves reconstructing the invention using a reference algorithm and dataset, to assess whether the outcome would have been predictable for an AI. However, this raises issues around data access, confidentiality, and examination efficiency. Sub-approaches to mitigate these concerns include using public datasets, treating data as part of the state of the art, or developing general-purpose datasets maintained by patent offices. Each presents its own trade-offs, particularly in balancing transparency and the protection of proprietary data.

Given these difficulties, the “Skilled Person 2.0” model offers a more balanced alternative. Rather than replacing the human expert with a machine, this hybrid concept integrates general

¹⁰⁸¹ Cesare Galli and Mariangela Boggi, ‘Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach’ (2020) 2 *Il Diritto industriale* 132; Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 435; Daria Kim, *Access to Non-Summary Clinical Trial Data for Research Purposes Under EU Law* (Berlin and Heidelberg 2021) 289.

¹⁰⁸² Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 94 et seq.

¹⁰⁸³ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 436; Daria Kim, *Access to Non-Summary Clinical Trial Data for Research Purposes Under EU Law* (Berlin and Heidelberg 2021) 290 et seq.

AI tools (as for example ChatGPT-4o as of 2025) into the skilled person’s “standard” capabilities. Moreover, depending on the technological field, the Skilled Person 2.0 may be an individual additionally proficient with specific AIs or a team including data science or AI specialists. Only those AI systems that are routine, widely adopted, and whose functioning is disclosed in the prior art are included in the assessment of obviousness. Therefore, determining what tools and knowledge should be attributed to the “Skilled Person 2.0” involves asking whether the AI tools are standard for the field, and whether insights derived from their use form part of common general knowledge. These tools are treated like other conventional research aids, such as databases or laboratory equipment, that enter the person skilled in the art’s knowledge base once they become standard practice.

To evaluate inventive step under this model, the key question is whether a skilled person using AI in a conventional, non-experimental way could have arrived at the invention. Complex configurations or reliance on non-standard datasets fall outside the scope of the skilled person’s normal practice. Human creativity remains central, especially where novelty lies in selecting particular datasets, configuring AI tools, or applying them in new contexts. The concept of a “reference AI”, a general-purpose model trained on public data, might serve as a benchmark for determining predictability.

Still, the model faces implementation challenges, including establishing when an AI system becomes standard, identifying the relevant tool version, and accounting for the datasets used. Since AI performance is data-dependent, the inclusion or exclusion of certain datasets can materially affect whether an invention is considered obvious. Proprietary or uniquely combined datasets should not be assumed part of the skilled person’s knowledge base, potentially preserving grounds for inventive step.

Finally, the proposal cautions against equating “human surprise” at AI outputs with non-obviousness. Legal analysis must focus on whether the invention would have been predictable to a skilled person using conventional AI tools. The Skilled Person 2.0 model therefore aims to strike a realistic balance: acknowledging the growing role of AI without overstating its implications for inventiveness and ensuring that patent law continues to incentivise both technological and human innovation.

VI. Approaches to Article 56 EPC and EPO Guidelines

1. De Lege Ferenda

Generally, inventiveness is defined as what lies beyond the capabilities of a person skilled in the art, achievable only through the development of the inventor’s skills and tools. As AI technology rapidly advances, the standards for what constitutes an inventive step are also evolving.¹⁰⁸⁴ If AI is not considered an ordinary tool and represents a unique choice by the inventor, it does not influence the criterion of inventiveness. However, as AI enhances the tools

¹⁰⁸⁴ Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.

available for experimentation, the capabilities of the person skilled in the art also advance, making them more adept at solving technical problems and thereby raising the bar for inventiveness. Patent offices may need to adapt their criteria to reflect the unique capabilities of AI, recognizing that AI can facilitate breakthroughs that human practitioners might not foresee, thereby expanding the definition of inventive activity.

It is debatable, if at the current state and foreseeable advancement of technology, a *de lege ferenda* approach to Article 56 EPC is needed. Generally speaking, any changes to the EPC should be carefully considered to ensure that they balance the need for innovation with the protection of intellectual property rights. In practice, if a new definition was to be adopted by the EPO, this would require changes to the EPC and/or adaptation of the EPO Guidelines.

Article 56 EPC currently states that “An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art. If the state of the art also includes documents within the meaning of Article 54(3) EPC, these documents shall not be considered in deciding whether there has been an inventive step”.

To adapt Article 56 EPC for AI-related inventions, several changes could be proposed to ensure that it adequately addresses the unique challenges and considerations posed by AI technologies. The following suggestions outline a potential framework for these amendments.

The first approach could be to retain the core elements of the original text that emphasise the importance of the state of the art and the role of a person or machine skilled in the art in determining whether an invention involves an inventive step. It would need to retain the exclusion of documents within the meaning of Article 54(3) EPC from consideration and reflect that this exclusion applies to the use of AI as well as to the judgment of a person skilled in the art.¹⁰⁸⁵ Moreover, it would need to recognise the role of AI in the inventive process and acknowledge that the skilled person or machine would have access to AI in carrying out their analysis. To include these observations the Article could be rephrased to “An invention shall be considered as involving an inventive step if, having regard to the state of the art, including the relevant artificial intelligence and excluding documents within the meaning of Article 54, paragraph 3, it is not obvious to a person skilled in the art or to a skilled person using artificial intelligence”. This change acknowledges that the skilled person in AI-related inventions may use AI tools as part of their analysis. By explicitly including AI in the definition, it reflects the current reality where AI systems can assist in problem-solving and innovation. The exclusion of documents within the meaning of Article 54(3) EPC from consideration would still be reflected. Article 54 EPC *per se* would not need to be amended, given that “public” can refer to both humans and non-humans.¹⁰⁸⁶

A second approach would be the alternative wording proposed by *Stierle*, “not obvious to a person or *object* skilled in the art,” which presents an interesting approach to adapting Article

¹⁰⁸⁵ The state of the art includes everything made available to the public by means of a written or oral description or by use, but that certain documents are to be excluded from consideration in determining whether an invention involves an inventive step.

¹⁰⁸⁶ Martin Stierle, ‘A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System’ (2021) *GRUR International* 128.

56 EPC to better accommodate AI-related inventions.¹⁰⁸⁷ By explicitly including “object” alongside “person”, this wording opens the door for the possibility of a “machine skilled in the art” instead a “person skilled in the art”. By using the term “object”, the proposal acknowledges that AI systems can possess skills relevant to the inventive process. This aligns with the growing recognition that AI can perform tasks traditionally associated with human inventors, potentially altering the landscape of patentability. The term also allows for a broader interpretation of what constitutes a skilled entity in the art, accommodating future advancements in technology and AI capabilities. Still, the term “object” is not clearly defined within patent law, which could lead to ambiguity in its interpretation. It may be necessary to establish specific criteria or guidelines for what constitutes an “object” to avoid confusion during patent examinations. Moreover, the use of “or” in the proposed wording does not clarify whether the assessment should consider both a person and an object simultaneously, whether either can suffice independently and most importantly if the “person” examines inventions by humans and the “object” the ones by AI-systems. This lack of clarity could complicate legal interpretations and patent evaluations.

Still, given the dynamic nature of the skilled person, which evolves alongside technological progress, it may not be necessary to amend the language of Article 56 EPC to explicitly mention AI. The preferred approach by the author would be to settle that the existing framework already allows for the assumption that, where appropriate, the skilled person has access to AI tools that are standard in the relevant field of technology. A suggested approach would continue to exclude documents under Article 54(3) EPC from consideration in the assessment of inventive step, regardless of whether the analysis is conducted by a human or with the assistance of AI. Rather than reformulating the provision to refer to “a skilled person using AI”, the better course may be to develop interpretative guidance at the level of the EPO Guidelines, clarifying how the problem-and-solution approach accommodates the integration of AI in inventive processes and in the assessment thereof.

All things considered, a *de lege ferenda* approach would require multiple players to agree on a new formulation, making changes to the text of the Convention rather difficult and at this point likely unnecessary. The main problem in the current phrasing is the term “person”. Still, “machine skilled in the art” approaches have been debated and rejected by this work. The “Skilled Person 2.0” seems the more fitting approach, but it would require updates to the Guidelines and not to the Convention to be introduced.

2. *De Lege Lata*

The problem can potentially be addressed otherwise at the current state of technology: instead of changing the provision of Article 56 EPC, a softer approach *de lege lata* could be to modify and update the EPO Guidelines, which are already updated yearly by the EPO.¹⁰⁸⁸ The

¹⁰⁸⁷ Ibid.

¹⁰⁸⁸ The EPO updates its Guidelines for Examination annually, with the new edition typically coming into force in spring. These Guidelines are published in advance on the EPO website, allowing stakeholders ample time to review and prepare for any changes. The EPO also engages with the public through consultations to gather feedback on

Guidelines should embrace the use of AI in the inventive process while retaining the human element in the definition of the skilled person.

a) The Extent of Human Oversight and Contribution

In order to establish the extent of human oversight and contribution required for an AI-related invention to be considered inventive, the EPO could consider factors such as:

- (a) the level of control that the human inventor exerts over the AI system (for example, whether the human inventor specifies hyperparameters, model architecture or training objectives),
- (b) the extent to which the human inventor provides input into the AI system’s decision-making processes (for example, whether the human evaluates and selects model outputs or refines learned weights), and
- (c) the extent to which the human inventor is involved in evaluating and selecting the AI-related output (for example, supervision or curation of AI-related outputs before filing).

These concrete factors would establish a threshold of human oversight and creativity, making clear that a hybrid approach, where both the human and the AI contribute, is necessary for an inventive step. EPO examiners would evaluate whether these elements deliver a “technical effect” required under the problem-and-solution approach.

Still, this work suggests focussing less on the inventive process and more on the invention. While the Guidelines can include a potential requirement for the disclosure of the use of AI in the patent application to ensure that the examiner is aware of the role of AI in the inventive process, this is merely to guide examiners and should not affect the patent examination.

Current updates to the Guidelines (for example to Part F-III 3)¹⁰⁸⁹ already highlight that training datasets and algorithmic methods must be disclosed in sufficient detail for a skilled person to reproduce the technical effect without undue burden. The Guidelines could now offer illustrative examples, for example where a human uses a neural network to generate control signals in a technical system rather than mere classification, to show how the human-machine interplay leads to technical contribution.

The Guidelines would also make clear that mere use of any algorithm on this list is *prima facie* ordinary, not inventive, unless the human inventor’s contribution yields a non-obvious technical effect. For example:

- (a) novel network architectures or training procedures;
- (b) innovative data curation, parameter tuning, or feature selection;

the Guidelines, ensuring they remain relevant and effective in guiding patent examination practices (EPO, ‘Guidelines for Examination in the European Patent Office’ (EPO, March 2024) <https://www.epo.org/en/legal/guidelines-epc>).

¹⁰⁸⁹ EPO Guidelines 2025, Part F-III, 3.

- (c) non-trivial integration of an AI model into a technical system yielding a technical effect beyond conventional expectations.

Moreover, the Guidelines should state how EPO examiners are required to have a level of expertise in the use of AI or otherwise how an expert panel should be established to provide guidance on the use of AI in the examination process.

b) Selection of Reference AIs

The EPO should select referenced AIs for each year and clarify that these can be used as “standard tools” by the “Skilled Person 2.0” if the patent was filed that year, independently of how the invention was generated and of the information in the patent disclosure. This would be applicable for inventions in all technical fields. As of 2025, the “Skilled Person 2.0” should be expected to use “general” AI/LLMs (for example “ChatGPT-4o”) both as an ideation and drafting tool in any field. It is also suggested that multiple AIs (ideally two or three) should be selected by patent offices, and if an invention is found obvious by all of them, it should be considered as lacking an inventive step.¹⁰⁹⁰

While the Guidelines do not mention specific models or focus on the inventive activity, they emphasise that AI tools used to prepare drafting submissions do not displace human responsibility, at least acknowledging that they are already used.¹⁰⁹¹ As of 2025, LLMs are accepted for drafting support but any claim interpretation or technical analysis must still rest on expert, proven sources, not AI outputs alone.¹⁰⁹² Still, the EPO would have to select referenced AIs for each year and clarify that these can be used as “standard tools” by the “Skilled Person 2.0”.

Moreover, the EPO could specify a list of established “specific” AIs deemed available to the skilled person at filing date for inventions in technical fields, where the use of specific AI systems is part of the common general knowledge. To be inventive, regardless of the use of AI, the contribution would need to add new technical effect.

The proposal consisted of three steps: (a) determining the extent to which a “specific” AI is used in the relevant field, (b) if AI is commonly used, identifying the AI that best represents the average worker in the field, and (c) evaluating whether the AI would find the invention obvious.¹⁰⁹³ This once again involves identifying specific AIs, since using actual AI rather than hypothetical AI would provide a more objective test. The last step is to determine whether the skilled person with a selected AI would find an invention obvious by testing whether the AI can reproduce the invention within a reasonable time.

¹⁰⁹⁰ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in R Lee, P Hilty and L Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 99 et seq.

¹⁰⁹¹ Harry Bedford, ‘EPO Guidelines 2025: What’s Changing?’ (Solve Intelligence, 7 February 2025) https://www.solveintelligence.com/blog/post/epo-guidelines-2025?utm_source=chatgpt.com.

¹⁰⁹² Rose Hughes, ‘An LLM is not (yet) a person skilled in the art (T 1193/23)’ (IPKat, 19 May 2025) https://ipkitten.blogspot.com/2025/05/an-llm-is-not-yet-person-skilled-in-art.html?utm_source=chatgpt.com.

¹⁰⁹³ Ichiro Nakayama, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 115 et seq.

This would be combinable with the “reproducibility test”. While reproducibility can supplement an evaluation of the technical merit of an invention, it cannot replace it.¹⁰⁹⁴ Focusing solely on reproducibility would undermine the disclosure function of the patent system, which is ensured by comprehensible patent specifications that can be understood by humans, not just machines.¹⁰⁹⁵ Still, in combination with the proposed “Skilled Person 2.0”, it can be applicable to AI-related inventions. Particularly in this case, the evaluation of the technical merit of an invention should be supplemented with the “reproducibility test”, which measures the ease with which an invention can be replicated by selected AI systems within a reasonable time, thereby offering a more objective criterion without relying solely on the hypothetical question of whether a person having ordinary skill in the art would have easily conceived the invention.¹⁰⁹⁶

c) Cooperative Agreements and In-House AI Systems

Considering multiple AI systems actively employed in the relevant field is important to obtain a comprehensive understanding of the state of the art. To facilitate this, the EPO could establish cooperative agreements with major AI providers to obtain copies of their AI systems and the associated datasets at intervals of six months. Alternatively the EPO could have access *in-situ*, allowing examiners to evaluate the systems’ capabilities without needing to possess the models and datasets themselves. This initiative would allow the EPO to maintain an accurate representation of AI capabilities at various points in time to examine patents with the technology available at the relevant date. Since the inventive step must be assessed as of the filing date, the AI expected to be used by the skilled person should be the one available at that time. Thus, the algorithm and dataset available at that time should be used.¹⁰⁹⁷

Still, although aligning AI capability assessment with the filing-date principle in patent law is conceptually coherent, its practical implementation would be challenging. For example, requiring major AI providers to supply the EPO with complete copies of their models and associated datasets every six months would face significant obstacles. These include intellectual property protection, trade secret considerations and licensing restrictions, as well as the significant technical demands of storing, maintaining and reproducing such systems, which may require highly specific hardware and software configurations. Additionally, dataset retention could raise legal concerns under instruments such as the GDPR, particularly where personal data are involved.¹⁰⁹⁸

¹⁰⁹⁴ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 150 et seq.

¹⁰⁹⁵ Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 322; Robert Plotkin, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business* (Stanford University Press 2009) 159.

¹⁰⁹⁶ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 42; Ryan Abbott, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020) 106.

¹⁰⁹⁷ *Ibid.*

¹⁰⁹⁸ Given the extensive data processing required for the effective advancement, training, and testing of AI systems, and considering the broad classification of personal data within data protection regulations, a significant proportion of this data falls under the purview of the GDPR and other associated data protection laws. Subject to further exploration, intellectual property and data laws should potentially establish more explicit and lenient provisions to exempt the development, training, and testing of AI systems from certain intellectual property protections,

A more practicable approach would be to grant the EPO *in-situ* access to relevant AI systems. This method would avoid the need to physically possess the models and datasets while enabling examiners to evaluate the systems' capabilities at a given point in time. However, it would require contractual guarantees that providers retain historical versions of their systems and permit controlled, time-stamped access to them for examination purposes. Implementation would also require robust confidentiality safeguards to protect proprietary information, as well as compliance with applicable data protection and competition laws. While the proposed mechanism is legally and conceptually aligned with the requirement to assess the inventive step as of the filing date, its execution would demand a carefully structured legal and technical framework. In practice, a model of *in-situ* access supplemented by formalised reproducibility procedures is likely to be the most viable way of enabling the EPO to accurately reflect the state of the art in AI at the relevant priority date. Still, the feasibility of such a system is debatable.

The EPO could further develop an in-house AI system that regroups all the external AI system to which it gains access. When the patent examiner analyses the invention, an automated process of uploading the description of the invention and the relevant date should tell the examiner if an AI system at the relevant time could have come up with the same idea. Similar to how AI systems assist the pharmaceutical industry in screening drug candidates, they could also aid patent examiners in filtering out unpatentable applications, thereby reducing the workload for examiners.¹⁰⁹⁹ The EPO has already implemented such an AI system to improve the efficiency of patent examinations, although its application seems to be primarily focused on searching patents, publications, and images, rather than directly examining patents.¹¹⁰⁰

3. Preliminary Results

While revising Article 56 EPC *de lege ferenda* to explicitly include AI as part of the inventive step analysis is an option, the proposal of this work suggests that a more flexible approach *de lege lata*, such as updating the EPO Guidelines, might be better. This would allow the EPO to provide clearer guidance on how AI should be integrated into the assessment of the inventive step and the role of the skilled person.

The concept of a “Skilled Person 2.0” represents an evolution in how patent law considers the hypothetical person skilled in the art, particularly in the context of AI-related inventions. This updated notion retains the fundamental principle of a hypothetical natural person or team while incorporating the increasing prevalence of AI tools in various technical fields. This hybrid

allowing for more efficient and legally compliant use of data in AI development. The GDPR, while housing provisions potentially capable of offering a broad research exemption (Article 5(1)(b) GDPR and Article 89 GDPR), currently lacks clarity regarding the extent to which such an exemption may cover processing personal data for AI system development, training, and testing. Given the pivotal role of data, especially personal data, and the absence of harm posed to data subjects by the processing of personal data within the development and testing of AI systems (with potential harm arising from the application of AI systems), it is advisable for the GDPR's research exemption to be interpreted in a manner that facilitates such data processing (For a general discussion see: Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 2 et seq.).

¹⁰⁹⁹ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 17-18.

¹¹⁰⁰ Conversation with an EPO representative in January 2024.

“Skilled Person 2.0” would include a person with AI-related knowledge, making use of AI technologies, or a team of experts that includes an AI specialist. This hypothetical individual is expected to use “general” AI technology and “specific” AI to the extent that the latter use would be common practice in the relevant technical field at the relevant date. The level of AI integration can vary depending on the specific technical field of the invention, reflecting the diverse ways in which AI is employed across disciplines. As of 2025, the “Skilled Person 2.0” would be expected to use “general” AI tools like ChatGPT 4-o in all fields and more sophisticated AI tools in fields where such tools have become standard practice at the relevant date.

While a legal idealist might expect the patent examiner’s perspective to align perfectly with that of a person skilled in the art, realistically, human examiners can only approximate the person skilled in the art standard as closely as possible. By incorporating a “Skilled Person 2.0”, the use of AI tools by patent examiners can help ensure that their perspective remains consistent with that of a person skilled in the art. AI tools in patent examination would aid in assessing the patentability of AI inventions by providing an enhanced understanding of the relevant field and the specific AI patent application under review.¹¹⁰¹

In conclusion, the current patent system already has characteristics that allow for adaptation to new technologies, and the use of tools such as the person skilled in the art can help to make case-by-case assessments of whether it is appropriate to grant a patent. Using alternative criteria to evaluate inventions, which are purportedly more objective than the opinion of a person skilled in the relevant field, should be rejected as a solution to maintain the current patent system. Until artificial general intelligence becomes a reality, it is unlikely that “everything will be obvious” for the “Skilled Person 2.0”, even though this might appear feasible in specific, well-defined fields of innovation.¹¹⁰²

¹¹⁰¹ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 18.

¹¹⁰² Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 6 et seq. stating that as AI becomes increasingly advanced, the threshold for patentability is expected to rise, with inventive efforts eventually deemed obvious. For a superintelligent AI, nothing would appear inventive, as every innovation would be considered self-evident.

E. REDEFINING THE STATE OF THE ART AND RELEVANT PRIOR ART FOR AI

I. Mapping AI's Influence on the State of the Art

1. The State of the Art and the Examination of the Relevant Prior Art

The state of the art is defined in Article 54 EPC as “everything made available to the public by means of a written or oral description, by use, or in any other way” before the date of filing of the European patent application, or its priority date”, including *everything* made available in *any* way, in *any* country, in *any* language, at *any* time¹¹⁰³ and today also may, at least in principle, include information about AI and how it may be deployed in that technological field (for example, drug discovery).¹¹⁰⁴

The state of the art inquiry is a wide-ranging investigation of existing knowledge on a particular subject. This inquiry can be broken down into two main components:

- (a) what knowledge is available to the public before the filing (or priority) date,¹¹⁰⁵ and
- (b) within that knowledge, what is considered “common general knowledge”.¹¹⁰⁶

The two main aspects of a state-of-the-art inquiry are therefore identifying *all* available knowledge and distinguishing between what is considered common general knowledge within that body of information.¹¹⁰⁷ Even if it has no direct connection to the invention being evaluated, all publicly available knowledge and technology is included in the state of the art and it is irrelevant, if on the priority or application date a member of the public actually *saw* the document or *knew* it was available.¹¹⁰⁸ The state of the art gives the invention context and aids in assessing the degree of technical development it represents. This involves gathering and analysing data from various sources, such as academic literature, expert opinions, and research studies.¹¹⁰⁹ Identifying the body of knowledge requires a concrete assessment of the intersection and proximity or remoteness of the sectors at that given moment in time.

¹¹⁰³ See for example, *Unilin Beheer BV v Berry Floor NV* [2007] FSR 25 [46] (Jacob J stating “my favourite pretend example is an anticipation written in Sanskrit wrongly placed in the children’s section of Alice Springs public library”); Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 192.

¹¹⁰⁴ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ (2022) *Queen Mary Law Research Paper No. 375/2022* 7.

¹¹⁰⁵ Article 54(1)(2) EPC.

¹¹⁰⁶ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ (2022) *Queen Mary Law Research Paper No. 375/2022* 7.

¹¹⁰⁷ Article 54(2) EPC defines the state of the art as “everything made available to the public by means of a written or oral description, by use, or in any other way, before the date of filing of the European patent application” where “everything”, refers to the information that is made available to the public at the relevant date.

¹¹⁰⁸ EPO, T 381/87, 10 November 1987 (*Publication*).

¹¹⁰⁹ As long as the information is available to one member of the public who is not barred from using it by the law, the patent examiner may take it into consideration. The knowledge contained in a discovery made by a third party that is kept secret, however, might not be considered to be part of the state of the art (Colin Birss et al., *Terrell on the Law of Patents* (19th edn, Sweet & Maxwell 2020) 11-27 *passim*; Noam Shemtov and Garry Gabison, ‘The

The state of the art and relevant prior art must both be considered when determining whether an invention is inventive.¹¹¹⁰ Although they have some similarities, “state of the art” and “relevant prior art” have different meanings. The relevant prior art refers to the knowledge and technology that already exist that are pertinent to the invention being evaluated and in determining whether the invention is novel and inventive considering the field’s existing knowledge and technology in the field, whereas the state of the art refers to the present level of knowledge and technology in a given sector. An existing commercialised product is the most relevant type of prior art, but prior art is any proof that the invention at stake is previously known.¹¹¹¹ It does not have to exist physically or be financially accessible. It is sufficient that somebody, in some place, at some point already has shown, described or made something that contains an application of invention that is fundamentally the same as the creation at stake.¹¹¹²

The most significant place for further prior art, is to look for example at EPO’s free database Espacenet, containing over 150 million reports, gathered and recorded over numerous years by patent offices in numerous nations.¹¹¹³

2. Changes with AI in the Mix

As AI becomes more advanced and omnipresent, it is necessary to consider how it affects the boundaries of the state of the art, which is the body of knowledge and technology that exists at a particular point in time and is relevant to assessing the inventiveness of an invention.

The integration of AI technologies has already influenced the first step of the examination process, particularly in the identification of prior art. As previously discussed, the invention must represent a significant technical advance over the prior art, which means that the invention must go beyond what is already known in the field and provide a new and non-obvious solution to a technical problem.¹¹¹⁴ This requirement may be easier to satisfy for AI-related inventions, since AI has the potential to create innovative solutions to technical problems, such as improving the accuracy or speed of data processing or enabling new applications of machine learning and natural language processing. Since the way in which the invention came about is not of particular importance and can also be the result of an error, the use or not of AI should not interfere with the usable criterion. If in a given field, a synergistic effect is not expected, it

Inventive Step Requirement and the Rise of the AI Machines’ (2022) *Queen Mary Law Research Paper* No. 375/2022 7).

¹¹¹⁰ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 192.

¹¹¹¹ EPO, ‘Inventors Handbook’, <https://www.epo.org/en/learning/learning-resources-profile/business-and-ip-managers/inventors-handbook> (stating that if one wants to find out if your invention is novel, they should search products past and present - but also search much further).

¹¹¹² Ibid, stating that there are no accurate statistics, but some experts estimate that for every recorded invention that eventually reaches the market, ten never will. This means that if one wants to find out if your invention is novel, they should search products past and present - but you should also search much further. The most important place for further prior art searching is the worldwide patent system.

¹¹¹³ EPO, ‘What is Espacenet?’ <https://www.epo.org/en/service-support/faq/searching-patents/espacenet-worldwide-patent-search/what-espacenet>.

¹¹¹⁴ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.; Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 139 et seq.

remains a worthwhile insight when assessing inventions having synergistic effects that came about through the involvement of AI.¹¹¹⁵

The inquiry can be divided into (a) the identification of prior art in the era of AI, (b) AI-related inventions as prior art, and (c) how AI affects the distance between prior art and the invention. AI can impact the inventive step in a variety of ways, in particular, it could lead to an expansion in the state of the art (or, to be more precise, of that knowledge that is relevant to the evaluation of the inventive step), an increase in the knowledge of the person skilled in the art and the tools at his or her disposal, and, consequently, a systematic reduction in the distance between the state of the art and AI-related inventions. The change in the state of the art and the skilled person's knowledge are intertwined.¹¹¹⁶ As previously seen, when the use of AI tools becomes part of common general knowledge, the skilled person will have to equip itself both with an AI system and an appropriate level of knowledge in the field of AI.

a) Identifying Prior Art in the AI Era

The first problem is identifying the prior art. The inventive step of an invention is measured on the gap between the state of the art and the invention.¹¹¹⁷ If the gap can be bridged by the person skilled in the art, the invention is not inventive enough to deserve patent protection. It is therefore important to assess whether the use of AI affects the gap between the state of the art and the invention. To do so, it is important to consider the use of AI within a specific sector. On the one hand, if in a given sector the use of AI closes the gap between the state of the art and the inventions in the field, patenting inventions may result in over-patenting and therefore a misalignment of reward and risk.¹¹¹⁸ On the other hand, if the use of AI significantly narrows the gap, changing the requirement for inventiveness may penalize inventors who do not use AI and therefore would not be granted patents.¹¹¹⁹

Therefore, firstly, the use of AI would be considered “normal” if it is widely recognised and accepted as a standard tool among experts in that field and therefore becomes “normal” once it

¹¹¹⁵ EPO, T 1814/11, 6 February 2013 (*Synergistische Fungizide Mischung/BASF SE*), § 3.5; Maurice Schellekens, ‘Artificial Intelligence and the re-imagination of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.

¹¹¹⁶ See *Conor Medsystems Inc. v Angiotech Pharmaceuticals Inc.*, The University of British Columbia, [2006] EWHC 260 (Pat), 2006 WL 503022, where it is stated: “the most difficult part of any obviousness case is the attribution of the relevant skill and knowledge to the notional addressee of the patent. When the common general knowledge is identified, the height of the bar is set”.

¹¹¹⁷ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.

¹¹¹⁸ Ibid; Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 2-53 passim; Enrico Bonadio, Luke McDonagh and Plamen Dinev, ‘Artificial Intelligence as Inventor: Exploring the Consequences for Patent Law’ (2021) 1 *Intellectual Property Quarterly* 48-66 passim; Robert P Merges, ‘Uncertainty and the Standard of Patentability’ (1992) 7(1) *High Technology Law Journal* 1 et seq.; Dan L Burk and Mark A Lemley, *The Patent Crisis and How the Courts Can Solve It* (The University of Chicago Press, 2009) 131-132.

¹¹¹⁹ Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 70-71; Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 25 et seq.; Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 865 et seq.

is mentioned in the referenced textbooks.¹¹²⁰ For example, AI is already being used in oncological pharmacology research to analyse large amounts of data and identify potential drug candidates.¹¹²¹ In such cases, where the use of AI is not a matter of pioneering and experimental use but a shared knowledge in the field, the mention of AI in reference texts or specialist literature can determine its status as part of the state of the art.¹¹²² By considering AI as prior art, secondly, AI-related knowledge should be considered when assessing the inventive step. If on the contrary AI is only used in a niche sector or in a limited way within a larger field, it is not considered part of the state of the art for that field. The prevalence of AI within a particular field is a crucial factor in determining whether it should be considered part of the state of the art.

Some argue that AI should always be considered prior art for inventions created using this technology,¹¹²³ while others suggest that AI may modify the enhanced knowledge. Alongside the common general knowledge, the other component of the state of the art is the enhanced knowledge, which is important in assessing the inventiveness of an invention, as it represents the knowledge that an expert would acquire when faced with a new problem.¹¹²⁴ The use of AI can modify this component when it is recurrently used in a field. In such cases, experts may need to consider whether AI could help solve a technical problem and take steps to find relevant information. Therefore, understanding the prevalence of AI within a sector is crucial to determine its impact on the boundaries of the state of the art.

¹¹²⁰ It is crucial to keep in mind that AI is an umbrella term that covers various technologies, including machine learning, deep learning, and evolutionary algorithm. These technologies have different capabilities and functions, for example needing a larger amount of data (machine learning) or more training (deep learning). Moreover, each subfield of AI has different subclasses based on various algorithms, and each AI tool serves a different purpose in the inventive process. Therefore, making generalizations about the use of AI in a field is insufficient to convince an expert, as they require more specific information about the technology involved. (Tommaso G Trabucco, 'The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person' (LLM Thesis, MIPLC 2021) 40.

¹¹²¹ On this point, see Claudio Luchini, Antonio Pea and Aldo Scarpa, 'Artificial Intelligence in Oncology: Current Applications and Future Perspectives' (2022) 126 *British Journal of Cancer* 4-9.

¹¹²² It could well be the case that patent offices assess that the latest advances in the state of the art, which are in some way present in the state of the art but require further elaboration, are not part of common general knowledge (see Noam Shemtov and Garry Gabison, 'The Inventive Step Requirement and the Rise of the AI Machines' in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423 et seq.).

¹¹²³ Joseph Straus, 'Some Lessons from "DABUS" Patent Applications' in R Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli, Turin 2021) 631.

¹¹²⁴ EPO, T 171/84, 24 October 1985 (*Redox Catalyst*); see also: Mario Franzosi, 'Non ovvietà' in *Studi di diritto industriale in onore di Adriano Vanzetti* (Giuffrè, Milan 2004) 573 et seq.

b) AI-Related Inventions as Prior Art

Straus introduces a compelling perspective regarding the definition of prior art for AI-related inventions.¹¹²⁵ He suggests that publicly accessible documents related to AI tools should be considered relevant prior art for the inventions they assist in creating.¹¹²⁶

His analysis, particularly through the lens of the DABUS patent applications, illustrates this point by referencing Thaler's assertion that the DABUS machine independently recognised the novelty of its invention. *Straus* contends that the US patent 5,659,666, which describes the "Creativity Machine", should be regarded as relevant prior art for the EP '144, the food container patent, because it outlines the capabilities of DABUS in generating inventive concepts. The US patent 5,659,666 mentions using the machine to design various items, including coffee mugs, while the EP '144 application includes containers for liquids. This perspective implies that any skilled person, including those with expertise in AI, would recognize these documents as pertinent when evaluating the inventive step.¹¹²⁷ Although this does not automatically make the EP '144 invention obvious, it could help in evaluating the inventive step requirement.¹¹²⁸ If the skilled person is construed as (including an) AI, documents detailing AI technologies will be included in the relevant state of the art.¹¹²⁹ Their inclusions in the patent specification might indeed assist patent offices in landscaping technical fields where AI tools are used to invent and thus properly construe the skilled person's model.¹¹³⁰ The US patent 5,659,666 would be considered a "pointer" towards using the disclosed AI system to design liquid containers.¹¹³¹ Thus, *Straus* seems to suggest that inventors should indirectly disclose in the applications their method of invention.

Given the rapid advancement of technology, locating relevant prior art and evaluating whether an invention is inventive can be challenging. Moreover, it may be essential to assess the non-obviousness of an invention based on its technical features and algorithms rather than relying solely on existing prior art. As the state of the art in AI continues to evolve rapidly, distinguishing between inventions and prior art becomes increasingly complex for both inventors and patent offices. The significant rise in AI usage across various industries has led to a corresponding increase in AI-related patent applications, complicating patent examiners' efforts to determine the extent of innovation relative to prior art.

Still, the prior art landscape for AI-related inventions should align with that of non-AI inventions to avoid disparities. Aligning the prior art landscape for AI-related inventions with

¹¹²⁵ Joseph Straus, 'Some Lessons from "DABUS" Patent Applications' in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli, Turin 2021) 625-627; the same argument was put forward also in Joseph Straus, 'Will Artificial Intelligence Change Some Patent Law Paradigms?' (2021) *Zbornik znanstvenih razprav / Univerza v Ljubljani, Pravna Fakulteta (Collection of Scientific Papers / University of Ljubljana, Faculty of Law)* 37-39.

¹¹²⁶ Ibid.

¹¹²⁷ Ibid.

¹¹²⁸ Ibid.

¹¹²⁹ Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 247-248.

¹¹³⁰ Joseph Straus, 'Some Lessons from "DABUS" Patent Applications' in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli 2021) 631.

¹¹³¹ Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 248.

that of non-AI inventions ensures that all inventions are evaluated under the same standards. This is crucial for maintaining equity in patent law, as it prevents potential biases against AI innovations that may arise from differing criteria or interpretations of what constitutes relevant prior art. Although AI-related inventions often involve complex inventive processes that may not be widely understood or recognized, if the prior art landscape for these inventions is narrower than that for non-AI inventions, it could lead to an incomplete assessment of novelty and inventiveness. By ensuring that both landscapes are aligned, patent examiners can better evaluate the factual inventive step of AI-related inventions. AI technologies draw from a wide range of fields, including computer science, mathematics, and statistics. Recognizing this extensiveness and integrating knowledge from these disciplines into the prior art landscape allows for a more holistic understanding of how AI contributes to innovation. This broader perspective is essential for accurately assessing the inventive step and ensuring that relevant prior art is not overlooked.

c) Distance from the Prior Art and the Invention

The second problem is determining how far the invention is from the state of the art. This can be particularly difficult in the case of AI-related inventions due to how quickly technology advances. Because of this, it is crucial to carefully evaluate the state of the art to make sure the invention represents a significant technical advance.

For AI-related inventions, *Granstrand's* theory, according to which the patentability criterion for the inventive step can be viewed as a spectrum, where the minimum distance between the state of the art and the claimed invention must be met to have a non-obvious invention, becomes interesting.¹¹³² *Granstrand's* model shows that increasing the inventive step standard threshold can lead to decreasing research and development expenditure, as researchers are less likely to invest in inventions with little likelihood of reward.¹¹³³ *Granstrand* argues that inventors undertake a cost-benefit analysis, and the inventive-step standard can be used to optimise research and development expenditure.¹¹³⁴ However, the use of AI-tools in research may complicate this approach: As AI-tools have large fixed costs and low marginal cost, researchers may be incentivized to use these tools for research projects with low expected benefits. This could lead to an increase in non-obvious inventions and patents granted, but it may not necessarily benefit society.

Even when the use of AI tools can be helpful in the inventive process, some information about their effectiveness may be kept as trade secrets and not be publicly available. Thus, making the state of the art dependable on whether information about AI tools, techniques, and applications is publicly accessible. Additionally, relying solely on textbooks to keep up with the latest state of the art may not be feasible given how rapidly evolving AI technologies are, meaning that

¹¹³² Ove Granstrand, 'Are We on Our Way in the New Economy with Optimal Inventive Steps?' (2003) *Economics, Law and Intellectual Property* 223-258 passim.

¹¹³³ Ibid.

¹¹³⁴ Ibid; see also: Tun-Jen Chiang, 'A Cost-Benefit Approach to Patent Obviousness' (2008) 82 *St John's Law Review* 42.

other sources of information such as academic and professional articles, but also websites, YouTube videos, and various social medias need to be considered.¹¹³⁵

The use of AI can be helpful because new solutions can emerge from ideas about state-of-the-art elements present in human memory, whose capacity is limited, while an AI has practically unlimited memory capacity.¹¹³⁶ Still, there are fundamentally two pathways to invention: combining components from existing state-of-the-art knowledge or discovering efficacy in known components previously unrecognized.

Even more critical in the context of AI is the structuring of the data used to train these systems, particularly in relation to the role of human input. The mere fact that the input data constitutes part of the state of the art does not mean that the output generated by the AI are likewise part of it. This remains the case even where the input data consists of standard datasets or encompasses all published patent applications without any selective filtering.

The uncertain scope of training data complicates defining prior art since AI does not inherently distinguish between “remote” fields.¹¹³⁷ This uncertainty makes it challenging to maintain consistent definitions; as standard systems become prevalent, what is deemed obvious could expand significantly - potentially rendering certain innovations unpatentable.¹¹³⁸

As systems gain traction in patent analysis and examination, there’s growing recognition that datasets used to train models may need consideration as part of state of the art due to their significant impact on capabilities.¹¹³⁹ Incorporating these datasets into assessments poses challenges since it requires evaluating both published documents and training data utilized by systems - expanding what needs consideration when determining novelty.

Since the state of the art in the field of AI is rapidly advancing, now more than ever before, it is increasingly difficult for both inventors and patent offices to distinguish inventions from the prior art. Still, the application of AI tools in patent offices for prior art search has partially solved the problem (Section E.II).

3. Relevance of Neighbouring or Remote Prior Art with AI

Some scholars propose that the advent of AI could diminish the distinction between closely related and more remote technical fields.¹¹⁴⁰ They argue that it is no longer practical to classify

¹¹³⁵ Noam Shemtov and Garry Gabison, ‘The Inventive Step Requirement and the Rise of the AI Machines’ (2022) *Queen Mary Law Research Paper* No. 375/2022 8.

¹¹³⁶ For a general discussion see: Sava Kulhavy, *Erfindungs- und Patentlehre: Methodik der Behandlung von Erfindungen und Patenten* (Carl Heymanns, Cologne 2009).

¹¹³⁷ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 2 et seq.; Roman Konertz and Raoul Schönhof, ‘Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?’ (2018) *Zeitschrift für geistiges Eigentum* 403 et seq.

¹¹³⁸ Andreas Engel, ‘Erfinderische Tätigkeit und Künstliche Intelligenz’ (2022) *GRUR* 864 et seq.

¹¹³⁹ Cesare Galli, ‘Intelligenza artificiale, ricerca e brevetti: cosa sta cambiando e le norme che servono’ (Agenda Digitale, 13 January 2020) <https://www.agendadigitale.eu/cultura-digitale/intelligenza-artificiale-ricerca-e-brevetti-cosa-sta-cambiando-e-le-norme-che-servono/>.

¹¹⁴⁰ Joel Nägerl, Benedikt Neuburger, and Frank Steinbach, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 338 et seq. (arguing that AI will be less tied to departmental boundaries or to

which prior art an AI might consult or integrate, as AI tools do not recognize such boundaries.¹¹⁴¹ Unlike humans, who may hesitate to combine disparate domains, AI can integrate knowledge from various fields without such constraints. However, this perspective oversimplifies the complexities of AI systems, which are not inherently comprehensive and can be limited by their training data and programming. While AI may mitigate some biases present in human reasoning, it can also perpetuate biases found in its training datasets. Therefore, the critical question remains whether a skilled person would use AI models to access prior art from both closely related and more distant fields. As AI tools become standard in patent analysis, particularly those capable of web browsing or accessing diverse datasets, the potential for a skilled person to draw from a broader range of prior art increases.

Abbott, for instance, suggests that a computer's database should not be restricted to specific subject areas.¹¹⁴² Unlike human inventors, who might not consider combining unrelated domains such as culinary arts with medical advancements, AI systems are not limited by these constraints.¹¹⁴³ *Ramalho* also contends that AI systems are less likely to be constrained by unfounded technical biases that typically affect human reasoning.¹¹⁴⁴

However, these arguments are somewhat overly simplistic and do not account for nuances. They generally apply to data-driven AI technologies like machine learning and expert systems, rather than evolutionary algorithms, which function differently. While machine learning models and expert systems are actually unaffected by document proximity or cognitive biases, it is inaccurate to assume that these tools are inherently comprehensive.¹¹⁴⁵

Expert systems, particularly in their traditional form, are limited by the specific expert programming they receive, including the knowledge base and inference mechanisms. Similarly, machine learning models are only as effective as the data they are trained with and the input they receive during operation. After training, these models do not retain the training data but

conventional patent classification, which have been so far based on human capabilities); Maurice Schellekens, 'Artificial Intelligence and the re-imagining of inventive step' (2022) 13(2) *JIPITEC* 97 et seq. ("because of greater efficiency with which AI can scour a search area, the threshold for considering a [neighbouring or general] field as a potential source for a solution may be lowered").

¹¹⁴¹ Kemal Bengi and Christopher Heath, 'Patents and Artificial Intelligence Inventions' in Christopher Heath, Anselm Kamperman Sanders, and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 141 ("nor is there a reason to confine the analysis to two prior art documents alone"); Tim W Dornis, 'Artificial Intelligence and Innovation: The End of Patent Law as We Know It' (2020) 23 *Yale Journal of Law & Technology* 127-128; Erica Fraser, 'Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law' (2016) 13(3) *SCRIPTed* 321; Liza Vertinsky, 'Thinking Machines and Patent Law' in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 503; Ralph D Clifford, 'Creativity Revisited' (2018) 59 *IDEA: The Journal of Law and Technology* 37. Considering whether AI might determine an "extension" to the state of the art see also: Laura Zoboli, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea 2023) 158-161.

¹¹⁴² Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1125.

¹¹⁴³ Ibid; see also: Ryan Abbott, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 37.

¹¹⁴⁴ Ana Ramalho, *Intellectual Property Protection for AI-generated Creations: Europe, United States, Australia and Japan* (Routledge 2021) 94.

¹¹⁴⁵ Tommaso G Trabucco, 'Artificial intelligence as a tool for research and development in European patent law' (PhD thesis, Bocconi University 2024) 243-244.

instead utilize it to recognize patterns and make predictions.¹¹⁴⁶ For example, a machine learning model can only generate insights based on the data it has been trained on or fed.¹¹⁴⁷

Regarding technical biases, while AI might overcome certain apparent barriers, it is also known that machine learning systems can inherit and perpetuate biases present in their training data.¹¹⁴⁸ Consequently, the claim that AI tools are less susceptible to technical biases is not entirely supported.

If a machine learning tool is included in the skilled person's common general knowledge, the critical question is whether the skilled person would have used the machine learning model with prior art from either closely related or more distant technical fields.¹¹⁴⁹ Similarly, for expert systems, the focus should be on whether the programmer would have included relevant information from specific fields in the knowledge base or inference engine.

Moreover, some machine learning systems are designed to access the internet. For instance, in March 2023, "ChatGPT 3.5" introduced a web browser plugin that enables it to browse the web, access website content, and generate responses based on this information.¹¹⁵⁰ Other plugins might allow such systems to analyse company documents and interact with additional AI systems.¹¹⁵¹ In such cases, it is more plausible that the skilled person's access to prior art could extend to more remote technical domains.

4. Preliminary Results

AI can affect the state of the art and the distance between the prior art and the invention in multiple ways.

Firstly, the state of the art, defined under Article 54 EPC, includes all publicly available information before the filing date of a patent application. This broad scope now potentially includes AI-related knowledge. As AI advances, its influence on the state of the art, the body of knowledge relevant to assessing the inventiveness of an invention, becomes significant. The prevalence of AI within a specific field is crucial in determining whether it should be considered part of the state of the art. When AI becomes a standard tool in a field, its use could be considered prior art, influencing the assessment of the inventive step.

Secondly, the rapid advancement of AI poses challenges for patent examiners, particularly in defining what constitutes relevant prior art and in evaluating the distance between an invention

¹¹⁴⁶ Josef Drexler et al., 'Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective' (MPI Research Paper No. 19-13, 10 October 2019) 8.

¹¹⁴⁷ Ana Ramalho, *Intellectual Property Protection for AI-generated Creations: Europe, United States, Australia and Japan* (Routledge 2021) 94 et seq.

¹¹⁴⁸ Karen Hao, 'This is how AI bias really happens - and why it's so hard to fix' (MIT Technology Review, 4 February 2019) <https://www.technologyreview.com/2019/02/04/137602/this-is-how-ai-bias-really-happens-and-why-its-so-hard-to-fix/>.

¹¹⁴⁹ Daniele Cerulla, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) 118-119.

¹¹⁵⁰ OpenAI, 'ChatGPT Plugins' (23 March 2023) <https://openai.com/blog/chatgpt-plugins#browsing>.

¹¹⁵¹ Neil Savage, 'Drug discovery companies are customizing ChatGPT: here's how' (2023) 41 *Nature Biotechnology* 585-586.

and the state of the art. The proliferation of AI-related prior art might raise the threshold for obtaining patents, making it increasingly difficult to secure patents in certain fields. AI can expand this body of knowledge, thereby narrowing the gap between existing knowledge and new inventions. This expansion affects how prior art is evaluated and how the inventive step is measured, particularly as AI tools become part of the common general knowledge. The use of AI tools in the invention process should decrease the number of obvious patents. AI could help identify and eliminate patents that do not meet the standard of being inventive. AI tools may also enable faster discovery or “mosaicking”, which involves combining different technologies or inventions to create something new.

Lastly, the ongoing debate among scholars regarding the role of AI in patent law centres on whether AI diminishes the distinction between closely related and remote prior art. Given AI’s ability to process and integrate information across various fields, some scholars argue that documents related to AI should always be considered prior art for inventions developed using these technologies. This perspective is exemplified by the DABUS case, where the patent application for a food container, conceived by an AI system, raised questions about the relevance of AI-related patents as prior art. Advocates suggest that including such documents in patent specifications would enhance the assessment of inventive steps and ensure a more comprehensive evaluation of patentability. The implications of this argument are significant. If AI-related documents are recognised as relevant prior art, it could lead to a broader understanding of what constitutes the state of the art, potentially impacting the patentability of new inventions. This shift may necessitate mandatory disclosure of AI-related prior art to provide patent examiners with the necessary context for evaluating inventive steps accurately. By acknowledging AI-related documents as part of the prior art landscape, patent systems could adapt to the evolving technological landscape, ensuring that inventions developed with AI tools are assessed fairly and consistently alongside traditional inventions.

II. Prior Art Search with AI at Patent Offices

1. Using AI in Prior Art Searches

The prior art search is an essential process for patent examiners to determine whether an invention is novel and inventive. The process involves searching for and reviewing previous patents, publications, and other forms of technical literature to assess whether the invention has already been disclosed or anticipated.

The most obvious application of AI in the patent world is the prior art search itself, where statistically significant similarities between patent documents are identified. AI technologies, such as natural language processing, machine learning, and data analytics, can greatly facilitate the prior art search process. With the increasing number of patent applications filed online and stored in databases, AI tools can help patent examiners efficiently and accurately search for relevant prior art documents by analysing and comparing their content, language, technical features, and citation patterns. AI algorithms can analyse millions of patent documents and identify statistically significant similarities and differences between them, allowing patent

examiners to focus on the most relevant documents and assess their inventiveness. This would result in an acceleration of the patent granting process and earlier publication of patent applications.¹¹⁵²

From the perspective of patent offices, AI systems and their outputs not only serve as subjects of evaluation but also function as operational tools. By not using AI in the prior art search, only what is available to a person would be considered, whilst what is available to a computer would not be treated as prior art. Consequently, computers could access and use inventions available to other computers but not to humans, often because not understandable, and therefore not considered prior art. On the contrary, if AI expands what is understandable by humans, it would be harder to establish an inventive step and thus patentability.¹¹⁵³

AI technologies can also help identify potential patent infringement and support patent litigation by analysing patent claims, identifying key technical features, and comparing them with existing patents and products.¹¹⁵⁴ The use of AI has the potential to significantly improve the efficiency, accuracy, and objectivity of patent examination and litigation processes. It is however worth noting that AI tools are not a substitute for human judgment and expertise, and patent examiners but also lawyers still need to review and interpret the results provided by AI.¹¹⁵⁵

Outside of patent offices, companies as for example Dennemeyer Octimine provide semantic patent search software and AI based analytics.¹¹⁵⁶ They offer AI-powered tools for prior art searches in patent law.¹¹⁵⁷ These tools leverage systems that are continuously fed with the latest patent collection's data from sources like Questel, IFI Claims, Clarivate, ktMINE, and Lighthouse intellectual property. These data providers play a crucial role in supplying high-quality and regularly updated patent information, ensuring the effectiveness and reliability of AI-driven prior art search tools.¹¹⁵⁸

¹¹⁵² According to Heiko Wongel (EPO), the application of AI technologies in patent proceedings still seems to be in its infancy (David Gelernter, 'Machines That Will Think and Feel: Artificial Intelligence is still in its Infancy - and that should scare us' (The Wall Street Journal, 18 March 2016) <https://www.wsj.com/articles/when-machines-think-and-feel-1458311760>).

¹¹⁵³ Liza Vertinsky, 'Thinking Machines and Patent Law' in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 489; for a general discussion see: William Samore, 'Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?' in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018).

¹¹⁵⁴ Aashish R Karkhanis and Jenna L Parenti, 'Toward an Automated First Impression on Patent Claim Validity: Algorithmically Associating Claim Language with Specific Rules of Law' (2016) 19 *Stanford Technology Law Review* 196 <https://law.stanford.edu/wp-content/uploads/2017/11/19-2-1-karkhanisparenti-final.pdf>.

¹¹⁵⁵ Personal communication from representatives of Octimine (Dennemeyer Group) (2023) <https://www.dennemeyer.com/octimine/>.

¹¹⁵⁶ Dennemeyer Group, 'Octimine' (Dennemeyer) <https://www.dennemeyer.com/octimine/>.

¹¹⁵⁷ Personal communication from representatives of Octimine (Dennemeyer Group) (2023) <https://www.dennemeyer.com/octimine/>.

¹¹⁵⁸ Ibid.

2. Patent Offices and AI in Patent Assessments

a) WIPO and EPO

WIPO actively promotes AI tool adoption by Intellectual Property Offices and facilitates information exchange amongst them. WIPO itself integrates AI across various aspects of its operations, encompassing automatic classification, search assistance, examination, formalities checks, and helpdesk services, along with machine translations. For instance, WIPO Translate serves to translate patent documents into eighteen different language pairs, accessible to the public and all intellectual property offices. WIPO's Global Brand Database leverages automated image searches to streamline research concerning visually similar trademarks and related brand data. "IPCCAT" software supports patent filers and examiners in assigning patent applications according to the International Patent Classification system.¹¹⁵⁹

Instead, in 2023, the EPO launched AI-PreSearch, an AI-driven tool designed to enhance the efficiency of the patent examination process. AI-PreSearch employs AI to assist patent examiners in identifying relevant prior art more effectively.¹¹⁶⁰ The EPO has transformed all prior art documents in their database into vectorized forms, creating a vast vector space with hundreds of millions of vectors. This effort led to the creation of a patent-specific language model called EP-RoBERTa, which had previously been used for automatic Cooperative Patent Classification. These AI tools play a significant role in the classification and allocation of patent applications, both within the EPO and under the Cooperative Patent Classification scheme. In addition to these capabilities, the EPO has incorporated machine learning solutions into prior art searches, aiding in the identification of relevant prior art.¹¹⁶¹

The EPO envisions further applications for machine learning and AI, particularly in detecting issues, proposing solutions for patent applications, and identifying non-patentable subject matter. Automated processes at the EPO also include the tagging of patent literature and the determination of the state of the art. The "Patent Translate" tool, trained with human-translated patent documents, facilitates continuous self-optimization by interfacing with the EPO databases. This tool helps overcome language barriers, particularly those related to examination materials from patent offices in China, Japan, and Korea. The performance of these AI programs is regularly assessed by comparing their results with those of human patent examiners and optimizing them accordingly, thus setting the machine's performance standard to human

¹¹⁵⁹ WIPO, 'WIPO Technology Trends' (WIPO) https://www.wipo.int/about-ip/en/artificial_intelligence/search.jsp?technology_id=&territory_id=400; Bruno Pouliquen, 'Advanced Technology Applications Center: Strategy for Developing AI Projects, List of Current AI Projects' (WIPO Meeting on ICT Applications and Artificial Intelligence for Intellectual Property Administration, Geneva, May 2018) https://www.wipo.int/edocs/mdocs/globalinfra/en/wipo_ip_itai_ge_18/wipo_ip_itai_ge_18_p16.pdf.

¹¹⁶⁰ Oliver Rigg, Lisa Williams and Gemma Robin, 'Patenting AI at the EPO and USPTO' (HLK, 7 May 2024) <https://www.hlk-ip.com/patenting-ai-at-the-epo-and-uspto/>; Michael Schmid, 'Revolutionizing Patent Examination: Will AI-PreSearch Transform the EPO's Approach?' (Richardt) <https://www.richardt.eu/en/news/detail/revolutionizing-patent-examination/>; Christina Sperry, 'Artificial Intelligence (AI) Takes a Role in USPTO Patent Searches' (Mintz, 8 November 2022) <https://www.mintz.com/insights-center/viewpoints/2231/2022-11-08-artificial-intelligence-ai-takes-role-uspto-patent>.

¹¹⁶¹ For more on the tools, see: Konrad Vowinckel and Volker D Hähnke, 'SEARCHFORMER: Semantic patent embeddings by siamese transformers for prior art search' (2023) 73 *World Patent Information* 102192, 10.1016/j.wpi.2023.102192.

levels. Moreover, the EPO is exploring the use of AI for the automated identification of problems and solutions within patent applications and the detection of patentability exclusions. This indicates a growing role for AI in substantive examination tasks traditionally performed by humans. To support these advanced applications, the EPO maintains its own data science team, which develops customized AI systems based on open-source software.¹¹⁶² This team ensures that the EPO remains at the forefront of leveraging AI and machine learning technologies to improve the efficiency and accuracy of patent examination processes.¹¹⁶³

b) Further Examples

In the United States, an evident policy response is for patent offices to employ AI technologies to expedite the examination process.¹¹⁶⁴ Notably, the USPTO has enlisted “Similarity Search”, an AI to categorize new patent applications, ensuring they are assigned to patent examiners with the requisite technological expertise.¹¹⁶⁵ The AI system uses models to quickly identify and retrieve references that are similar to the application being examined. Examiners can fine-tune these results by using classification data to focus on specific aspects of the patent in question. The use of AI in the search process is intended to increase the likelihood of finding relevant prior art early in the examination, potentially shortening the time between the start of prosecution and the grant of the patent, as the most pertinent prior art can be addressed sooner. Additionally, the AI tool may help uncover prior art that might otherwise have gone unnoticed, potentially improving the overall quality of patents.¹¹⁶⁶

¹¹⁶² WIPO, ‘Index of AI initiatives in IP offices’, https://www.wipo.int/about-ip/en/artificial_intelligence/search.jsp?technology_id=&territory_id=33.

Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 34-35.

¹¹⁶³ Jean-Marcel Krausen, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Tübingen 2023) 315-316.

¹¹⁶⁴ Drawing from past experiences, the USPTO encountered a substantial influx of patent applications in the 1990s related to express sequence tags (ESTs) or small DNA fragments. The USPTO estimated that reviewing these EST patent applications in its queue would take a single examiner over 90 years and cost the agency upwards of \$ 20 million. Consequently, then-USPTO Commissioner Bruce Lehman explored various strategies to address the growing backlog, including proposals that required patent applicants to conduct more comprehensive prior art searches themselves or outsource this research. Applying similar strategies to AI-generated patent applications presents certain challenges, notably the need for any contractor to access AI tools of comparable sophistication to those used by leading applicants. (See: Elliot Marshall, ‘Patent Office Faces 90-Year Backlog’ (1996) 272 *Science* 643).

¹¹⁶⁵ USPTO, ‘PTOC-016-00, Privacy Impact Assessment: USPTO Serco Patent Processing System (PPS)’ (2018); Serco, ‘Serco Processes 4 Millionth Patent Application for US Patent and Trademark Office’ (15 November 2018) <https://www.serco.com/na/media-and-news/2018/serco-processes-4-millionth-patent-application-for-us-patent-and-trademark-office> (“since 2006, Serco has performed classification and other analysis services through awarded contracts including Pre-Grant Publication (PGPubs) Classification Services, Initial Classification and Reclassification (ICR) Services, and Full Classification Services (FCS) contracts”).

¹¹⁶⁶ Oliver Rigg, Lisa Williams and Gemma Robin, ‘Patenting AI at the EPO and USPTO’ (HLK, 7 May 2024) <https://www.hlk-ip.com/patenting-ai-at-the-epo-and-uspto/>; Michael Schmid, ‘Revolutionizing Patent Examination: Will AI-PreSearch Transform the EPO’s Approach?’ (RichardT, 7 August 2024) <https://www.richardt.eu/en/news/detail/revolutionizing-patent-examination/>; Christina Sperry, ‘Artificial Intelligence (AI) Takes a Role in USPTO Patent Searches’ (Mintz, 8 November 2022) <https://www.mintz.com/insights-center/viewpoints/2231/2022-11-08-artificial-intelligence-ai-takes-role-uspto-patent>.

The USPTO also collaborates with foreign intellectual property offices through patent work-sharing arrangements to enhance examination efficiency. This collaborative approach enables patent offices to jointly examine patent applications that have been filed concurrently, reducing redundancy in researching questions related to patentability.¹¹⁶⁷ The Patent Prosecution Highway programs exemplify such work-sharing efforts, where partial examination in one office can expedite the review of the same application in another office.¹¹⁶⁸ While these programs have resulted in faster and more cost-effective patent reviews, their impact remains limited given the vast number of patent applications filed annually. Moreover, there have been considerations within the USPTO regarding the integration of an “AI-based search platform” to assist patent examiners in uncovering prior art pertinent to a given application.¹¹⁶⁹ AI holds substantial promise in enhancing the search process associated with patent examination, including the identification of relevant sections within prior art, their alignment with the current application’s claims, and the consequent generation of potential rejections. However, it is worth noting that AI may not be as effective in reviewing patent applications pertaining to emerging subject matters where inventors are pioneering entirely new patentable technologies. Furthermore, it is unlikely that legislators would endorse fully autonomous examination, which is granting traditional patent rights without any human involvement. Some level of human intervention in the patent examination process may be necessary to satisfy due process rights of patent applicants or administrative law’s requirements for reasoned decision-making under current legal norms. Effectively managing the surge in patent numbers would necessitate patent offices to adopt AI tools as advanced as those employed by the most sophisticated applicants, which appears challenging.¹¹⁷⁰

At the Intellectual Property Office of Singapore, efforts are underway to develop an assistive feature employing Natural Language Processing and machine learning tools to validate the formalities of patent applications. A patent auto-classification tool leveraging Natural Language Processing for classifying patent applications and aiding examiners in comprehending patent documents is also being explored.¹¹⁷¹

The United Kingdom Intellectual Property Office similarly embraces AI tools, using a patent translate tool, powered by machine learning, to optimise the allocation of patent applications among examiners, leading to time efficiencies and improving accuracy over time.¹¹⁷² Although certain AI-enabled initiatives have been discontinued, such as a project on AI-driven patent prior art searches, the United Kingdom Intellectual Property Office remains enthusiastic about AI’s potential in various sectors, encompassing automated text searches with Natural Language Processing, automated guidance, and pre-apply services across all intellectual property rights,

¹¹⁶⁷ Warren K Mabey, Jr, ‘Deconstructing the Patent Application Backlog... A Story of Prolonged Pendency, PCT Pandemonium & Patent Pending Pirates’ (2010) 92 *Journal of the Patent and Trademark Office Society* 208 et seq.

¹¹⁶⁸ Toshinao Yamazaki, ‘Patent Prosecution Highways (PPHs): Their First Five Years and Recent Developments Seen from Japan’ (2012) 34 *World Pat Info* 279; US Patent & Trademark Office, ‘Performance and Accountability Report’ (2021) <https://www.uspto.gov/sites/default/files/documents/USPTOFY21PAR.pdf>.

¹¹⁶⁹ USPTO, ‘Patent Public Advisory Committee Quarterly Meeting: IT Update’ (2018).

¹¹⁷⁰ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1467.

¹¹⁷¹ ‘Workshop 3’ (Center for Information Technology, Society, and Law (ITSL), University of Zurich) <https://www.cipco.uzh.ch/de/veranstaltungen/IP-KI/politische-rechtliche-Gestaltung.html>.

¹¹⁷² The AI reportedly improved already from 60% to 80% accuracy.

and advanced authentication and validation features to enhance application quality.¹¹⁷³ Collaboratively, the United Kingdom Intellectual Property Office is collaborating with the EPO to advance AI search tools.¹¹⁷⁴

Furthermore, the Swiss Intellectual Property Office employs AI to automate administrative functions, including decision-making, document creation, and real-time fee and deadline management. Notably, since 2018, the Swiss Intellectual Property Office has been training a self-learning AI system for document classification, fine-tuning outcomes through manual adjustments when necessary.¹¹⁷⁵

3. Preliminary Results

The prior art search is an essential process for patent examiners to determine whether an invention involves an inventive step. This process involves searching for and reviewing previous patents, publications, and other forms of technical literature to assess whether the invention has already been disclosed or anticipated. The most obvious application of AI in the patent world is the prior art search itself, where statistically significant similarities between patent documents are identified. AI tools, while useful in prior art searches, do not replace human judgment and expertise. Still, AI technologies can facilitate the prior art search process. With the increasing number of patent applications filed online and stored in databases, AI tools can help patent examiners efficiently and accurately search for relevant prior art documents by analysing and comparing their content, language, technical features, and citation patterns. AI algorithms can analyse millions of patent documents and identify statistically significant similarities and differences between them, allowing patent examiners to focus on the most relevant documents and assess their inventiveness. This would result in an acceleration of the patent granting process and earlier publication of patent applications.

Moreover, AI technologies can also help identify potential patent infringement and support patent litigation by analysing patent claims, identifying key technical features, and comparing them with existing patents and products. The use of AI has the potential to significantly improve the efficiency, accuracy, and objectivity of patent examination and litigation processes.

Patent offices globally are increasingly adopting AI to improve the speed, accuracy, and consistency of patent examination. WIPO promotes AI use among national offices and employs it internally for classification, translation (for example, WIPO Translate) and trademark searches. The EPO has developed tools such as AI-PreSearch and EP-RoBERTa to assist in

¹¹⁷³ The office conducted a trial of a patent search tool called “Derwent Innovation”, which takes large volumes of plain text as input. It performs searches across patent documents as well as nonpatent literature. A feature of this tool is its ability to assign different weights to terms, allowing the searcher to rank results in a contextually relevant manner. However, as pointed out by *Oliviere*, the system still relies on human involvement during input selection and the interpretation of results (WIPO, ‘Index of AI initiatives in IP offices’, https://www.wipo.int/about-ip/en/artificial_intelligence/search.jsp?technology_id=&territory_id=62).

¹¹⁷⁴ United Kingdom Intellectual Property Office, ‘IPO’s First AI-Powered Tool Improves Quality of TM Applications’ (GOV.UK, 15 November 2022) <https://www.gov.uk/government/news/ipos-first-ai-powered-tool-improves-quality-of-tm-applications>.

¹¹⁷⁵ WIPO, ‘Index of AI initiatives in IP offices’, https://www.wipo.int/about-ip/en/artificial_intelligence/search.jsp?technology_id=&territory_id=33.

prior art searches and classification. Moreover, it continues to explore AI applications for detecting patentability issues. These systems are benchmarked against human examiners, with development supported by an internal data science team.

In the United States, the USPTO uses AI tools like “Similarity Search” to classify applications and identify relevant prior art, aiming to reduce examination time and improve quality. It also participates in international work-sharing programs, though full automation remains unlikely due to legal constraints and the complexity of emerging technologies. Singapore’s IP Office is developing AI tools using Natural Language Processing and machine learning to validate application formalities and support classification. The United Kingdom Intellectual Property Office uses AI for application allocation and continues to explore Natural Language Processing-based tools in collaboration with the EPO. Switzerland’s IP office uses AI for administrative tasks and has trained a self-learning classification system since 2018.

These efforts reflect a broader trend of integrating AI to support, but not replace, human-led patent examination.

F. SUFFICIENCY OF DISCLOSURE IN THE LIGHT OF AI

I. Examination of the Current Standard of Disclosure under the EPC

1. The Role of Sufficiency of Disclosure

As previously seen, the assessment of the inventive step under the EPC is strongly linked to the problem-and-solution approach¹¹⁷⁶ formalised within the EPO Guidelines,¹¹⁷⁷ which also shaped European national judicial practice.¹¹⁷⁸ This approach is supported by Rule 42(1)(c) Implementing Regulations of the EPC, that indicated that the description must disclose the invention, as claimed, in such terms as to allow understanding both of the objective technical problem, even when it is not expressly indicated as such, and of its solution, as well as to indicate the possible advantageous effects of the invention with reference to the prior art.¹¹⁷⁹ With the information provided, the person skilled in the art, an expert that possesses the normal/ordinary means and capacities for work in the sector and experimentation that are normal for the field of technology in question (AI included), should be able to replicate the invention without undue experimentation.¹¹⁸⁰

The approach under consideration aims to reduce the discretionary nature of the inventive step analysis, avoiding an *ex post* judgement in patent evaluation. Thus, the examiner must visualise the general state of the art *before the* patent application and make an assessment of the relevant factors.¹¹⁸¹ The ratio of this approach is to avoid that those examining the patentability requirements are conditioned by their knowledge of the invention and end up finding obvious, *a posteriori*, the technical solution whose patenting is sought.¹¹⁸²

¹¹⁷⁶ On this point, see EPO, T 24/81, 13 October 1982, (*Metal refining/Basf AG*), § 4, where it states that: “[w]hen assessing inventive step for this method, it is not a question of the subjective achievement of the inventor, so that the case history of the invention presented at the oral proceedings is irrelevant. It is rather the objective achievement which has to be assessed. As in the case of novelty, inventive step is an objective concept. Objectivity in the assessment of inventive step is achieved by starting out from the objectively prevailing state of the art, in the light of which the problem is determined which the invention addresses and solves from an objective point of view [...], and consideration is given to the question of the obviousness of the disclosed solution to this problem as seen by the man skilled in the art and having those capabilities which can be objectively expected of him”.

¹¹⁷⁷ EPO Guidelines 2025, Part F-III, 1.

¹¹⁷⁸ On the Italian approach see: Giorgio Floridia, ‘I requisiti di proteggibilità’ in P. Auteri et al. (eds), *Diritto industriale: proprietà intellettuale e concorrenza* (Giappelli 2020) 297.

¹¹⁷⁹ EPO, G 1/19, 10 March 2021 (*Pedestrian simulation*).

¹¹⁸⁰ EPO Guidelines 2025, Part G-VII, 3; see also: Peter Blok, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 71.

¹¹⁸¹ EPO Guidelines 2025, Part G-VII, 8; on this point see Cesare Galli and Mariangela Boggi, ‘Il requisito di brevettabilità dell’attività inventiva’, in C. Galli and A. Gambino (eds), *Codice Commentato della Proprietà Industriale ed Intellettuale* (UTET 2011) 580; Vincenzo Di Cataldo, *L’originalità dell’invenzione* (Giuffrè Editore, 1983) 81 (stating that the assessment of non-evidence is undeniably a value-based judgement, retaining subjective elements that can never be entirely removed); Giuseppe Sena, ‘I diritti sulle invenzioni e sui modelli industriali’, in A. Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè 2011) 125 (stating that the judgement of non-evidence implies an assessment that is by its very nature debatable).

¹¹⁸² Kaisa Suominen et al., *Visser’s Annotated European Patent Convention* (Wolters Kluwer, Alphen aan den Rijn 2022) 213; of a different view: Cesare Galli, ‘Per un Approccio Realistico al Diritto dei Brevetti’ (2010) *Il Diritto Industriale* 136 (stating that the problem-and-solution approach is said to prevent two key pitfalls: first, the risk of a posteriori analysis revealing something as obvious, much like Columbus’ egg, when it was not obvious).

While the problem-and-solution approach primarily serves the assessment of inventive step, its interplay with the requirement of sufficiency of disclosure under Article 83 EPC becomes relevant where the plausibility of the solution is in question, as an insufficiently disclosed invention cannot credibly solve the technical problem it purports to address.

The concept of sufficiency of disclosure is therefore a fundamental requirement for patent applications. It involves ensuring that the invention is described in enough detail and clarity that a person skilled in the art can fully understand it and be able to carry it out “without undue burden”.¹¹⁸³ Disclosure requirements typically pertain to the specific details of the invention and the inventive process, rather than the broader context of the technology in the field. It concerns only the invention, whereas the research and development process and the tools adopted by the inventor(s) currently do not need to be disclosed.¹¹⁸⁴

This requirement is explicitly mentioned in Article 29(1) TRIPs agreements, which highlights the importance of providing a clear and complete disclosure of the invention in the patent application.¹¹⁸⁵ Under the EPC, the concept of adequacy of disclosure is termed “sufficiency of disclosure”. According to Article 83 EPC, a European patent application must disclose the invention clearly and completely enough for a person skilled in the art to carry it out.¹¹⁸⁶ This requirement is technologically neutral, applying equally to all types of inventions. Specifically, the description must provide sufficient detail on all essential features so that a skilled person can implement the invention without undue effort and without requiring inventive skills.¹¹⁸⁷ Patents are therefore only granted if the invention works as disclosed and the scope of protection is supported by the disclosure (Article 84 EPC).¹¹⁸⁸ It is important to focus on what information is truly useful for a skilled person. Since the application is intended for someone skilled in the art, it is not necessary to include well-known ancillary details. However, the description must adequately detail any essential features to ensure the skilled person can implement the invention.¹¹⁸⁹

The EPO Guidelines allow for some trial and error, especially in unexplored fields like certain areas of AI. To fully meet the requirements, the invention must be described in terms of both its structure and function, unless the functions are immediately apparent. In some fields, such as AI, a clear functional description may be more suitable than a detailed structural description.¹¹⁹⁰

beforehand; and second, the less common but equally problematic error of assuming a non-existent problem. This constructed problem can make a solution appear non-obvious in hindsight, leading to the unjustified granting of a patent that should not have been approved).

¹¹⁸³ EPO, T 32/85, 5 June 1986, § 5.

¹¹⁸⁴ Tommaso G Trabucco, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) 262.

¹¹⁸⁵ According to Article 29(1) TRIPs, “Members shall require that an applicant for a patent shall disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art and may require the applicant to indicate the best mode for carrying out the invention known to the inventor at the filing date or, where priority is claimed, at the priority date of the application”.

¹¹⁸⁶ Article 83 EPC.

¹¹⁸⁷ EPO Guidelines 2025, Part F-III, 1.

¹¹⁸⁸ Martin Müller, ‘Issues in Patenting Artificial Intelligence from an EPO Perspective’ (2024) 19(3) *JIPLP* 8 <https://doi.org/10.1093/jiplp/jpad114>.

¹¹⁸⁹ EPO Guidelines 2025, Part F-III, 1.

¹¹⁹⁰ EPO Guidelines 2025, Part F-III, 1.

The EPO's Guidelines provide guidance on how to assess the sufficiency of disclosure.¹¹⁹¹ The EPO considers whether the description of the invention provides enough information to allow a skilled person to carry out the invention and whether the description is clear enough to be understood by a skilled person. The EPO may also consider the level of skill in the art and the state of the art at the time of filing the application.

The purpose of sufficient description is to ensure that the innovative knowledge for which an exclusive right is sought is fully disclosed. The disclosure of the invention is the consideration for the exclusivity of exploitation that the law attributes by patenting.¹¹⁹² Additionally, the sufficient description contributes, along with the claims, to clearly delineating the perimeter of the exclusivity conferred by the patent title.¹¹⁹³ The sufficient description ensures that the applicant for a patent application is aware of the invention for which they are seeking protection. As part of the monopolistic justification for the patent, the patentee must disclose to the public a significant amount of technical information relating to the invention.¹¹⁹⁴ The assessment of sufficient description also takes a person skilled in the art as a benchmark. Sufficient description plays a crucial role in the patent system by balancing the interests of inventors and the public. On one hand, inventors are granted exclusive rights over their inventions, which incentivizes them to disclose their innovative knowledge and make it available to the public. On the other hand, the public is given access to the technical information necessary to implement the invention after the exclusivity has ceased. This ensures that society as a whole can benefit from the progress made by inventors and promotes further innovation and technological advancement. If the public does not derive any benefit from the invention due to insufficient description, the patent system would fail to achieve one of its main objectives. Ultimately, sufficient description promotes innovation and technological advancement, which benefits society.¹¹⁹⁵

The sufficiency of disclosure poses a problem for AI. A common issue in AI patent applications is the insufficient disclosure of the AI model and its training process. To mitigate this problem, applicants should provide comprehensive descriptions of the model's architecture, training data, and operational parameters. This level of transparency ensures that a skilled person can reproduce the invention, effectively addressing potential sufficiency objections.

Thus, an invention that at first sight appears inventive could be the obvious result of an AI to create. Any invention that emerges from a computer performing multiple calculations or tests may appear non-obvious, because it was not anticipated. Nonetheless, the invention can be viewed as obvious due to the unavoidability of the discovery, as anybody with regular competence would have been able to achieve the exact same effect if they had used an AI

¹¹⁹¹ EPO Guidelines 2025, Part F-III, 1.

¹¹⁹² Andrea Ottolia, 'Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30', in L C Ubertaini (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (7th edn Wolters Kluwer 2019) 256.

¹¹⁹³ Ibid; see also: Luigi Sordelli, 'Il paradigma della "persona esperta del ramo" nella legge sulle invenzioni' in *Studi in onore di Remo Franceschelli* (Giuffrè 1983) 231.

¹¹⁹⁴ Clark D Asay, 'Artificial Stupidity' (2019) 61(5) *William & Mary Law Review* 1208; Jeanne C Fromer, 'Patent Disclosure' (2008) 94 *Iowa Law Review* 553.

¹¹⁹⁵ EPO Guidelines 2025, Part F-III, 1; Ana Ramalho, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 17; Catherine Seville, *EU Intellectual Property Law and Policy* (2nd edn, Edward Elgar 2018) 183.

algorithm. As this knowledge should be attributed to the expert, it is not equivalent to a later evaluation forbidden by the condition that the inventive step needs to be assessed without understanding the alleged invention as claimed.¹¹⁹⁶ Not taking into account the knowledge of AI technologies in the assessment of obviousness, would lead to the granting of unjustified monopolies at the place where the technologies are used, which could hinder innovation. The uppermost standard ought to be followed also in those cases where invention-generation technology is not applied; otherwise, the application of the current minor standard would be tantamount to rewarding lack of knowledge of the state of the art.¹¹⁹⁷

2. Debating the Disclosure of AI Models and Datasets

a) Complications Related to Datasets

The current AI boom depends mainly on large amounts of data, and enough computing power to process it.¹¹⁹⁸ As the data economy continues to surge in value, with an estimated worth of EUR 829 billion in 2025 compared to EUR 301 billion in 2018, the value and importance of training data and the resulting datasets has also grown exponentially.¹¹⁹⁹ Still, there is currently a lack of clear legal guidance on how data can and should be regulated.¹²⁰⁰ Access to large and/or diverse datasets is essential for the development of accurate AI algorithms.¹²⁰¹ AI is highly dependent on the quality and availability of data, a relationship often described by the principle of “garbage in, garbage out”.¹²⁰² These systems learn patterns from the data provided to them, which means they can replicate not only intended but also flawed or socially problematic structures.¹²⁰³ Since the quality of an AI’s work is significantly dependent on the

¹¹⁹⁶ *Windsurfing International Inc v Tabur Marine (GB) Ltd* [1985] RPC 59; *Pozzoli SPA v BDMO SA* [2007] EWCA Civ 588.

¹¹⁹⁷ Ross D King et al., ‘The Robot Scientist Adam’ (2009) 42(7) *Computer* 46 et seq.

¹¹⁹⁸ Melissa Heikkilä, ‘Generative AI Risks Concentrating Big Tech’s Power: Here’s How to Stop It’ (MIT Technology Review, 18 April 2023).

¹¹⁹⁹ Sarah Bußmann et al., ‘Die Schutzfähigkeit von KI-Trainingsdaten *de lege lata*’ (2022) *RD* 391.

¹²⁰⁰ On intellectual property protection of data and training data for AI see, amongst others: Ansgar Ohly, ‘Zuweisung von Daten: immaterialgüterrechtliche Lösungen’ in Franz Hofmann, Boris Raue and Herbert Zech (eds), *Eigentum in der digitalen Gesellschaft* (Tübingen 2022) 135-150; Matthias Leistner, ‘Big Data and the EU Database Directive 96/9/EC: Current Law and Potential for Reform’ in Sebastian Lohsse, Reiner Schulze and Dirk Staudenmayer (eds), *Trading Data in the Digital Economy: Legal Concepts and Tools* (Baden-Baden 2017) 25-58; Philipp Hacker, ‘Immaterialgüterrechtlicher Schutz von KI-Trainingsdaten’ (2020) GRUR 1025; Heike Schweitzer, Alex Metzger, Knut Blind and Heiko Richter et al., ‘Data Access and Sharing in Germany and in the EU: Towards a Coherent Legal Framework for the Emerging Data Economy: A Legal, Economic and Competition Policy Angle – Final Report (Expertenstudie im Auftrag des Bundesministeriums für Wirtschaft und Klimaschutz)’ (2022).

¹²⁰¹ On the current value of data see, for example: Chris Stokel-Walker, ‘Twitter’s \$ 42000-per-Month API Prices Out Nearly Everyone’ (Wired, 10 March 2023) <https://www.wired.com/story/twitter-data-api-prices-out-nearly-everyone/>.

¹²⁰² Monique F Kilkenny and Kerin M Robinson, ‘Data Quality: “Garbage in – Garbage out”’ (2018) 47(3) *Health Information Management Journal* 103; Kenny Choo et al., *Machine Learning kompakt* (Berlin 2021) 67.

¹²⁰³ A widely cited example is a neural network developed by Google for image recognition, which incorrectly identified dark-skinned individuals as gorillas. However, this outcome should not be interpreted as evidence of a “racist AI”, but rather as a manifestation of a systematic error rooted in a non-representative training dataset (see: Katharina Weitz, ‘Was „denkt” Künstliche Intelligenz? Wie wir sichtbar machen, wie intelligent KI wirklich ist’ in Michael C Bauer and Laura Deinzer (eds), *Bessere Menschen? Technische und ethische Fragen in der transhumanistischen Zukunft* (Berlin and Heidelberg 2020) 77, 89; Viktoria Schrön, *Künstliche Intelligenz im*

quality of the implemented data, regulating them will be essential in order not to create barriers to the development and deployment of AI systems.¹²⁰⁴

As society moves from a traditional industrial capitalism towards an data-based economy, one of the key obstacles is establishing a legal framework that effectively regulates data access and usage.¹²⁰⁵ In relation to current major research trends such as biotechnology, AI, and big data, having access to fundamental information for extensive data processing is crucial.¹²⁰⁶ However, obtaining access to high-quality training data can be challenging, as many data sources are controlled by third parties who may be unwilling or unable to share their data. There may also be privacy and security concerns associated with sharing sensitive or personal data, which can make it difficult to obtain the data required for training AI algorithms. The re-use of training data is also an issue, as AI algorithms that are trained on old or outdated data may produce inaccurate results or become irrelevant in the face of changes in the real-world phenomena, they are modelling.

The inventive processes associated with AI systems often involve intricate algorithms and extensive data processing that can be challenging to describe. For example, deep learning models may rely on vast datasets and complex training methodologies that are not readily reducible to simple explanations. Moreover, AI inventions can vary significantly based on the specific data used for training, the architecture of the neural networks, and the intended applications. This variability makes it hard to establish a standardised method for disclosure that would satisfy patent requirements across different cases.

Although patent and copyright laws, along with other intellectual property protection frameworks, comprise provisions permitting the use of protected content for research and development purposes, it remains uncertain whether the prevailing exemptions are sufficiently comprehensive and consistent across various jurisdictions to accommodate both the requisite data usage by AI systems and the disclosure of the datasets for patent law purposes.¹²⁰⁷ In practice, training datasets are rarely protected under copyright or patent law.¹²⁰⁸ Rather, protection is more commonly sought under the *sui generis* database right or through trade secret law.¹²⁰⁹ Current exceptions and limitations do not adequately address the balance between AI data usage and disclosure.¹²¹⁰

Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz (Baden-Baden 2023) 45).

¹²⁰⁴ Ibid.

¹²⁰⁵ For more on data access and how to regulate it see: Heike Schweitzer and Axel Metzger, 'Data Access under the Draft Data Act, Competition Law and the DMA: Opening the Data Treasures for Competition and Innovation?' (2023) *GRUR International* 337 et seq.; For a more general discussion see: Manuel Castells, *The Rise of the Network Society* (2nd edn, Wiley Blackwell 2010); Julie E Cohen, *Between Truth and Power: The Legal Constructions of Informational Capitalism* (OUP 2019); Matthias Leistner, 'The Existing European IP Rights System and the Data Economy – An Overview With Particular Focus on Data Access and Portability' in J Drexel (ed), *Data Access, Consumer Protection and Public Welfare* (Baden-Baden 2021) 209.

¹²⁰⁶ Matthias Leistner, 'Towards an Access Paradigm in Innovation Law?' (2021) *GRUR International* 930.

¹²⁰⁷ Josef Drexel et al., 'Position Statement on IP Law and Artificial Intelligence' (MPI Research Paper No. 21-10, 9 April 2021) 11 et seq.

¹²⁰⁸ Ibid, 6.

¹²⁰⁹ Philipp Hacker, 'Immaterialgüterrechtlicher Schutz von KI-Trainingsdaten' (2020) *GRUR* 1032.

¹²¹⁰ In particular Article 4(3)(c) of the Trade Secrets Directive, Article 3(1) and Article 7(1) of the Digital Single Market Directive; see also: Heike Schweitzer and Axel Metzger, 'Data Access under the Draft Data Act,

For the purposes of this analysis, a comprehensive treatment of intellectual property protection for data is not considered strictly necessary.¹²¹¹ Nonetheless, in the context of potential disclosure obligations for training datasets, the protectability of such datasets becomes a relevant consideration. While existing intellectual property regimes offer certain research exemptions, the extent to which these exceptions are sufficiently robust and harmonised across jurisdictions remains unclear, particularly in view of both the use of datasets in AI system development and the potential requirement to disclose it.

b) The “Black Box” Problem

AI systems have the potential to alter the traditional analysis of the person skilled in the art, impacting not only inventions developed through AI tools but the assessment of inventiveness more broadly. Within examination procedures, AI technologies enhance examiners’ ability to access and process vast amounts of data with increasing sophistication, thereby supporting determinations of novelty and inventive step. Nonetheless, applicants remain responsible for clearly identifying the technical effect achieved by the invention. Challenges may arise when AI systems cannot fully elucidate the technical contribution they facilitate, a manifestation of the so-called AI “black box” or explainability issue, which examiners must consider during the assessment and complicates the disclosure process.¹²¹²

The rules by virtue of which AI processes data and makes decisions are subject to different levels of (human) knowledgeability depending on the technologies used. In opaque systems, the so-called “black box”,¹²¹³ the rules according to which the software makes decisions are largely developed by the machine and are not fully known by humans. In transparent systems, the so-called “clear box”,¹²¹⁴ the knowledgeability of the rules is full (although with different

Competition Law and the DMA: Opening the Data Treasures for Competition and Innovation?’ (2023) *GRUR International* 337 et seq.

¹²¹¹ On the topic see, amongst others: Ansgar Ohly, ‘Zuweisung von Daten: immaterialgüterrechtliche Lösungen’ in Franz Hofmann, Boris Raue and Herbert Zech (eds), *Eigentum in der digitalen Gesellschaft* (Tübingen 2022) 135-150; Matthias Leistner, ‘Big Data and the EU Database Directive 96/9/EC: Current Law and Potential for Reform’ in Sebastian Lohsse, Reiner Schulze and Dirk Staudenmayer (eds), *Trading Data in the Digital Economy: Legal Concepts and Tools* (Baden-Baden 2017) 25-58; Philipp Hacker, ‘Immaterialgüterrechtlicher Schutz von KI-Trainingsdaten’ (2020) *GRUR* 1025.

¹²¹² The problems posed by the doctrine with reference to the “black box” mainly concern computer implemented inventions, since the very functioning of the algorithm is (to a greater or lesser extent) the subject matter of the patent, and not mere means of realising a different invention (Raphael Zingg, ‘Foundational Patents in AI’ in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (OUP 2021) 90 et seq.).

¹²¹³ The process developed through learning remains in reality unknowable to humans (and for this reason they are referred to as black box models): it is not humans who give the machine the values to be attributed to various coefficients: only indirectly it is possible to understand, for example, if among the rules considered relevant in an evaluation of criminal probability, there is also the ethnicity or the degree of schooling. Human beings have no evidence of the exact decision-making process pursued (See Riccardo Guidotti et al., ‘Factual and Counterfactual Explanations for Black Box Decision Making’ (2019) 34(6) *IEEE Intelligent Systems Journal* 14-15).

¹²¹⁴ “Clear box” or “white-box” systems, instead, offer full transparency in machine decision-making by detailing each step leading to a conclusion. For example, decisions may consider factors such as age, zodiac sign, or ethnicity. If certain parameters are identified as erroneous or inappropriate, they can be excluded. However, these systems are limited by their binary structure, which is not well-suited for complex issues. Alternatively, logic learning machines provide accurate decisions through comprehensible models (See Enrico Ferrari and Marco Muselli, ‘Efficient Constructive Techniques for Training Switching Neural Networks’ in L Franco, J M Jerez et al. (eds), *Constructive Neural Networks* (Berlin 2009) 25 et seq.; Marco Muselli and Diego Liberati, ‘Training

levels of effectiveness).¹²¹⁵ The point is that the transparency of AI systems affects both the possibility of resolving the “errors” present in automated decision-making processes (which then correspond to problems of efficiency or lawfulness) and, more generally, the possibility of guaranteeing the individual the knowledgeability of the decision-making processes that concern him.¹²¹⁶

Thus, the term “black box” is commonly used to describe the nature of AI systems, particularly deep neural networks, which often operate in ways that are not easily explainable or replicable, even by their developers.¹²¹⁷ Despite their powerful capabilities, deep neural networks rarely offer insight into innovation processes. The inventive process can be hard to conceptualize and describe, particularly when discovered through serendipitous means or extensive research paths.¹²¹⁸

This lack of transparency complicates the patenting process, specifically the enablement requirement under Article 83 EPC.¹²¹⁹ Many AI systems evolve through extensive training on vast datasets, obscuring the specific processes that lead to their outputs. The EPO has indicated that failing to disclose critical details can result in refusals based on insufficient disclosure.

While AI-systems are occasionally characterized as “black boxes” due to the limited explainability of their computational outcomes, this generalisation cannot be universally applied because the complexity of models can significantly vary.¹²²⁰ Moreover, the comprehensibility of a model depends on the perspective of the observer; for example, the training process may not be perceived as a “black box” to someone involved in training the model. When concerns arise regarding interpretability, particularly with respect to the correlations predicted by a trained model, the focus is on understanding the causality between data points. However, these challenges do not indicate a lack of human control over the training and application of the model or the inherent irreproducibility of the model itself. Several factors contribute to the limited explainability of artificial neural network models, including non-

Digital Circuits with Hamming Clustering’ in 47(4) *IEEE Transactions on Circuits and Systems - I: Fundamental Theory and Applications* (2000) 513 et seq.; Marco Muselli, ‘Approximation Properties of Positive Boolean Functions’ in B Apolloni et al. (eds), *Neural Nets. Lecture Notes in Computer Science* (Berlin and Heidelberg 2006) 18 et seq.).

¹²¹⁵ Christian Bauckhage, Johannes Fürnkranz and Gerhard Paaß, ‘Vertrauenswürdigen, transparentes und robustes Maschinelles Lernen’, in Günther Görz et al (eds.), *Handbuch der Künstlichen Intelligenz* (3rd edn, Oldenbourg Wissenschaftsverlag 2018) 571, 575; Aurélien Géron, *Machine Learning mit Scikit-Learn & TensorFlow* (2nd edn, O’Reilly 2020) 180.

¹²¹⁶ Riccardo Guidotti et al., ‘Factual and Counterfactual Explanations for Black Box Decision Making’ (2019) 34(6) *IEEE Intelligent Systems Journal* 15 et seq.

¹²¹⁷ Martin Ebers, ‘Regulierung von KI und Robotik’ in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) 90 et seq.

¹²¹⁸ Ariel Bleicher, ‘Demystifying the Black Box That Is AI’ (Scientific American, 9 August 2017) <https://www.scientificamerican.com/article/demystifying-the-black-box-that-is-ai/>.

¹²¹⁹ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 12.

¹²²⁰ Will Knight, ‘The Dark Secret at the Heart of AI’, (MIT Technology Review, 11 April 2017) <https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/>.

linearity, complex data representations within the network, and a lack of understanding regarding the causality of statistical correlations revealed during training.¹²²¹

However, not all of these factors are relevant for meeting the requirement of sufficient disclosure.¹²²² For instance, if patent claims are directed towards a method of identifying anomalous patterns in data, the reasons behind these anomalies may not be crucial for satisfying the disclosure requirement. The main point is that the limited explainability of an artificial neural network does not imply an inability to consistently reproduce it. In general, reproducing a model necessitates a detailed specification of the training process, including the algorithm and criteria for data selection. If randomization is employed, reproducibility can be achieved by disclosing the specific random number generator and “seeds” used. Explaining how the algorithm identified the invention is different from explaining how the invention works and can be replicated industrially. What’s crucial is that the invention itself, regardless of how it was realized, is described in a manner that is understandable to skilled person.¹²²³

Achieving an exact reproduction of an AI-system may not always be necessary. Patent disclosure is considered sufficient if it enables a skilled person to reproduce the technical concept underlying the claimed invention. A robust machine learning algorithm consistently delivers reliable results when executed. Consequently, models trained using the same algorithm will exhibit a comparable level of accuracy, even if individual weights may slightly differ due to randomization. Since artificial neural network are nonlinear functions consisting of numeric values (weights), they can be regarded as components of “mixed” inventions, where their contribution to the claimed technical effect may vary. Meeting the requirement for sufficient disclosure in this context involves enabling a skilled person to train a model that effectively fulfils its function within the overall invention.¹²²⁴

c) Implications of the Disclosure of Training Datasets

Article 83 EPC requires that the patent application disclose the invention sufficiently for it to be carried out by a person skilled in the art. In the context of AI inventions, the key issue is whether the specific dataset used to train the model must be disclosed to meet this standard. If the invention relies on a trained model whose technical functionality or performance is dependent on the particular characteristics of the training dataset, disclosure of that dataset may

¹²²¹ Ariel Bleicher, ‘Demystifying the Black Box That Is AI’ (Scientific American, 9 August 2017) <https://www.scientificamerican.com/article/demystifying-the-black-box-that-is-ai/>.

¹²²² Giuseppe Sanseverino, ‘Ex machina. La novità e l’originalità dell’invenzione “prodotta” dall’IA’ (2018) *AIDA* 15.

¹²²³ This criticism has been acknowledged by the same authors who put forward this hypothesis. See, for example: Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 13 (who recalls a 1923 case in which the Court of Appeals held that the sufficiency of disclosure should be judged according to the difficulty or novelty of the art in question, the development of that art, the kind and degree of skill that must be present to apply it, and the particular invention in question (*A B Dick Co v Barnett* 288 F 799 (2nd Cir 1923)), but states that the enablement requirement concerns only the invention itself, not the method of inventing it).

¹²²⁴ Josef Drexler et al., ‘Position Statement on IP Law and Artificial Intelligence’ (MPI Research Paper No. 21-10, 9 April 2021) 17.

be essential. Unlike traditional inventions where a person skilled in the art can reasonably understand and replicate the invention, AI-related inventions may transcend the comprehension of the person skilled in the art due to the intricate layers of neural networks and data-driven decision-making processes. While a skilled person in the field may possess the requisite AI expertise and general knowledge, the absence of the specific training dataset used in the invention can render the claimed technical teaching irreproducible. As a result, it may be necessary to provide additional information, such as sample code or datasets, to enable a person skilled in the art to carry out the invention.

The question arises whether the disclosure of the training dataset is necessary for the skilled person to carry out the invention, how the data should be disclosed, how it should be treated and its availability per se. Assume that the skilled person (or team) possesses relevant AI expertise, the prior art includes relevant AI material, and the common general knowledge covers AI-related information and equips the skilled person with the relevant mental acumen, without the suitable data the skilled person cannot perform. To arrive at the invention, the skilled person may require access to certain datasets that have been used to train the relevant AI system that assisted the inventive process that led to the invention.¹²²⁵ Data and its possession become the key for evaluating obviousness. Certain research output may be obvious only once the requisite data for training and optimising an AI becomes part of the state of the art. For example, in the pharmaceutical industry, relevant data may be sourced from physicians and clinics, patients, caregivers, and more. Such datasets are often not publicly available, as they are generated in-house and kept as trade secrets.¹²²⁶

The key consideration is whether the dataset forms part of the invention's core technical teaching. If the inventive contribution lies in how the model performs a technical function as a result of being trained on a specific dataset, then the dataset is not merely incidental, it is an integral component. Without access to it, the skilled person may be unable to reproduce the invention or understand how the technical effect is achieved.

However, full disclosure of training datasets raises legitimate concerns. These include data privacy, confidentiality, and the economic value of proprietary datasets. This is particularly pertinent in fields such as pharmaceuticals or diagnostics, where datasets may include sensitive patient data or proprietary clinical trial results. These datasets are rarely in the public domain. Moreover, the sheer volume and complexity of many datasets pose practical challenges for disclosure in patent applications. Nevertheless, if their disclosure is necessary to carry out the invention, the legal obligation under Article 83 EPC may override confidentiality interests.

To reconcile these competing interests, a nuanced approach is required. Rather than mandating disclosure of entire datasets, it may suffice to provide representative samples, detailed

¹²²⁵ Noam Shemtov and Garry Gabison, 'The Inventive Step Requirement and the Rise of the AI Machines' (2022) *Queen Mary Law Research* Paper No. 375/2022 16.

¹²²⁶ For example, see Roche to acquire Flatiron Health to accelerate industry-wide development and delivery of breakthrough medicines for patients with cancer, at: Charoline Chen, '23andMe Gives Pfizer Genetic Data in Startup's Growth Quest' (Bloomberg, 12 January 2015) <https://www.bloomberg.com/news/articles/2015-01-12/23andme-gives-pfizer-dna-data-as-startup-seeks-growth>; Gemma Jones 'Amgen Signs Real World Study and Mobile Data Partnership' (PMLiVE, 4 September 2017) http://www.pmlive.com/pharma_news/amgen_real_world_study_and_mobile_data_partnership_1203895.

descriptions of the dataset's structure, or the parameters used in its generation and pre-processing. Where datasets are publicly available, appropriate references may be included. Where they are proprietary, mechanisms to allow controlled access under confidentiality agreements might be explored.

In terms of disclosure requirements, the goal of patent law is to promote the progress by encouraging innovation and making new inventions publicly available. As a result, in order to be eligible for patent protection, an inventor must fully and completely disclose the details of their invention to the public. Still, once disclosed, any competitive advantage derived from proprietary datasets could be lost, allowing others to utilize this information without restrictions. While some may argue that sharing data promotes further innovation and development, others contend that without protection, there may be reduced incentives for companies to invest in data collection and curation necessary for effective AI training. Establishing tailored guidelines for safely disclosing AI-related inventions datasets can help ensure that only necessary information is shared. This could include a focus on high-level descriptions of algorithms and their functionalities rather than detailed datasets, thereby protecting proprietary training data while still providing sufficient information for reproducibility.

For the disclosure of training datasets, the current system of exceptions and limitations alone cannot resolve the balance problem in the context of AI. Introducing a broad research exemption that encompasses database usage for AI system development, training, and testing becomes imperative. Importantly, such an exemption would not confer standalone access rights to database data but rather enable research-oriented data usage when prior access has been granted under contractual terms, often accompanied by remuneration.¹²²⁷ While a suitable interpretation of the research exemption constitutes a preliminary step, additional research is warranted to devise a fitting data usage framework. Establishing comprehensive data access and usage rights, encompassing personal and non-personal data, would facilitate AI system development, training, testing and disclosure. Simultaneously, such carve-outs must not inadvertently condone intellectual property right infringements.¹²²⁸

d) The Need for Enhanced Disclosure Obligations in Patent Law

In conventional patent law, inventors are not required to reveal the process by which their invention was conceived. As previously seen, under the EPC, only the invention itself, rather than the steps or thought processes leading to it, is protected, and the sufficiency of disclosure requirement in Article 83 EPC means that the claimed invention must be disclosed in a way that enables a person skilled in the art to carry it out without undue burden. Typically, the origin of an invention, outside AI contexts, is immaterial to patentability assessment.

¹²²⁷ For a discussion on the Swiss Research Exemption see: Peter G Picht, Valerie Brunner and Rena Schmid, 'Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action' (MPI Research Paper No. 22-08, 28 May 2022) 32.

¹²²⁸ Josef Drexler et al., 'Position Statement on IP Law and Artificial Intelligence' (MPI Research Paper No. 21-10, 9 April 2021) 12 et seq.

However, as AI-related inventions proliferate, the adequacy of this traditional model comes into question.¹²²⁹ AI systems, especially those characterised as “black boxes”, often generate outputs through internal reasoning processes inaccessible to human observers. This opacity challenges whether existing disclosure standards suffice, given the epistemological and evidentiary peculiarities inherent to AI.

Several scholars have argued that, in light of the growing prevalence of AI inventions, the patent system should consider requiring disclosure not just of the invention as such but also of the inventive process involving AI.¹²³⁰ In many cases, achieving reproducibility may depend critically on information about the AI model architecture, the characteristics of training datasets, or the training regimen, elements that are typically not required for conventional inventions but may be crucial in AI contexts.¹²³¹

Indeed, although applicants need not generally disclose specific training datasets, the EPO Guidelines 2025 include an example stating that in the field of AI if the (mathematical methods and) “training datasets are disclosed in insufficient detail for the skilled person to be able to reproduce the technical effect without undue burden using common general knowledge over the whole scope of the claim”,¹²³² sufficiency of disclosure cannot be acknowledged “if the skilled person has to carry out a research programme based on trial and error to reproduce the results of the invention, with limited chances of success”.¹²³³ Decisions such as T 0161/18 and T 1191/19 reinforce this necessity, emphasising that applications must disclose neural-network topology, activation functions, learning mechanisms, and input data characteristics in sufficient detail so that a skilled person could reproduce the technical teaching across the full scope of the claim.¹²³⁴

Consequently, as explained in the following subchapters, it may be appropriate to reconsider whether current disclosure obligations need to be expanded for AI inventions. Such enhanced disclosure would aim to ensure meaningful transparency for both patent offices and third parties regarding the contribution of AI to inventive activity, thereby fostering replicability, legal certainty, and trust in the patent system.

¹²²⁹ Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1079, 1104; Erica Fraser, ‘Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law’ (2016) 13(3) *SCRIPTed* 332.

¹²³⁰ See for example: Jeremy A Cubert and Richard G A Bone, ‘The Law of Intellectual Property Created by Artificial Intelligence’ in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 421.

¹²³¹ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 39.

¹²³² EPO Guidelines 2025, Part F-III, 3; see also: EPO Guidelines 2025, Part G-II, 3.3.1.

¹²³³ EPO Guidelines 2025, Part F-III, 3; EPO, T 38/11, 21 May 2015 (*Synergistic biocides/SOLENIS TECHNOLOGIES CAYMAN L.P.*), § 2.6.

¹²³⁴ Tom Woodhouse, ‘Sufficiency of AI Inventions at the EPO’ (Page White Farrer, 5 March 2024) <https://www.pagewhite.com/news/sufficiency-of-ai-inventions-at-the-epo>; Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* <https://doi.org/10.1093/jiplp/jpae063> 834, 838.

e) Theories Favouring a Disclosure Obligation of AI

Different theories have been elaborated regarding the necessity to adjust the current laws and guidelines adding an “inventive process” disclosure obligation.¹²³⁵

Ramalho suggests that patent offices’ examination guidelines should mandate the disclosure of the inventive process.¹²³⁶ This means that the patent applicant would be required to reveal how the invention was created in order to receive a patent. This proposal aims to increase transparency and prevent the granting of patents based on inventions that were not genuinely invented by humans.¹²³⁷

Similarly, *Stanková* proposes an amendment to Rule 42 Implementing Regulations of the EPC, which would require the disclosure of AI systems used in inventing the invention as part of the objective technical problem and solution. Patent applicants should be required to disclose the role of an AI-driven system, if any, in devising the subject matter in a manner enabling to conduct an adequate patentability assessment. Such a disclosure could be part of the description of the objective technical problem and solution according to Rule 42(1)(c) Implementing Regulations of the EPC.¹²³⁸ The applicant would be obliged to disclose if, and to what extent, an AI-driven system was used and describe the steps in the process that were undertaken by it. Failure to comply with this requirement would result in the EPO refusing the patent application under Article 90 EPC. Whenever an applicant fails to explain the steps undertaken by an AI-driven system and their significance, the EPO should refuse the application under Article 90 EPC for not complying with the formal requirements of patentability. The disclosure would enable examiners to determine whether the invention possesses the required creative and intellectual inventive quality in relation to the technical features of the subject matter.¹²³⁹ This proposal also aims to ensure transparency in the patent system and prevent the granting of patents based on AI-related inventions without the involvement of human inventors.¹²⁴⁰

Straus adopts a different approach, proposing that AI tools employed during the inventive process be treated as state of the art (prior art) for the purposes of assessing patentability.¹²⁴¹ Consequently, such tools, and the outputs they are capable of producing, should be disclosed, either through amendments to the Implementing Regulations or via a revision of the EPO Guidelines. This proposal raises complex questions. One might initially question whether widely available AI systems, such as ChatGPT or similar models, already constitute part of the state of the art by virtue of their public accessibility. If so, the application of such tools by the

¹²³⁵ Anne-Marie Verschuur et al., ‘Summary Report, 2021 – Study Question Inventiveness and sufficiency of disclosure in AI inventions’ (AIPPI, 20 July 2021) 33; Tabrez Y Ebrahim, ‘Artificial Intelligence Inventions & Patent Disclosure’ (2020) 125(1) *Penn State Law Review* 147 et seq.

¹²³⁶ Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 26 et seq.

¹²³⁷ *Ibid.*

¹²³⁸ EPO Guidelines 2025, Part F-II, 4.

¹²³⁹ Sherman argued about the disclosure of biological resources and indigenous knowledge for understanding their contribution to scientific and technical advancements (Brad Sherman, ‘Regulating Access and Use of Genetic Resources: Intellectual Property Law and Biodiscovery’ (2003) 25 *EIPR* 307 et seq.).

¹²⁴⁰ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 26-27.

¹²⁴¹ Joseph Straus, ‘Some Lessons from “DABUS” Patent Applications’ in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli 2021) 631.

skilled person would appear to be obvious. However, this analysis must be nuanced. While the use of general-purpose AI tools might be foreseeable, the specific inventive outputs they produce remain inherently unpredictable due to the non-deterministic and opaque nature of these systems. Therefore, it cannot automatically be concluded that inventions resulting from the use of known AI systems lack inventive step solely because the tool itself is widely available. The fact that a tool like ChatGPT is publicly known does not render its outputs obvious to the skilled person. This discrepancy highlights a fundamental challenge: the distinction between the foreseeability of a tool's application and the predictability of its outcomes. Thus, a requirement to disclose the inventive process may be necessary to contextualise the specific contribution made by the AI system and to clarify whether the human inventor exercised any creative control.¹²⁴²

From a United States perspective, *Abbott* is in favour of a requirement for patent applicants to disclose the use of computers in the invention process, as failure to do so can render a patent unenforceable.¹²⁴³ The purpose is to determine if most inventors in a field are human or machine.¹²⁴⁴ However, in the United States, the level of technological advancement is already taken into account in assessing non-obviousness. Additionally, the US Patent Act states that patentability cannot be negated by the manner in which the invention was made, making it unlikely that a disclosure requirement regarding the inventive process would be considered.¹²⁴⁵ Some argue that AI-related inventive processes should be disclosed under the “duty of candour rules”.¹²⁴⁶ The duty of candour provides that patent applicants and their attorneys have a “duty to disclose to the USPTO all information known to that individual and material to patentability”. Still, a violation of the duty of candour constitutes “inequitable conduct”, or even “fraud”, and can lead to the invalidity or unenforceability of the patent.¹²⁴⁷ Based on this provision, US case law tends to disfavour references to “routine” testing and experiments in obviousness analysis, as it is seen as an intrusion into how the invention was made. It is difficult to imagine that any proposal to introduce a disclosure requirement concerning the “manner in which the invention was made” would be even considered by United States legislators and courts.¹²⁴⁸ It is debatable

¹²⁴² Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 34; Joseph Straus, ‘Some Lessons from “DABUS” Patent Applications’ in Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli 2021) 627 (Thaler’s previous patent, called US ‘666 (n 56), made a claim about a Creativity Machine that supposedly had the ability to create various items, such as a coffee mug (as stated in column 2, lines 5-18). Considering that EP ‘144 (n 126) claims a food container that is particularly suitable for liquids, it is possible to regard US ‘666 as prior art for this patent).

¹²⁴³ Ryan Abbott, ‘Everything Is Obvious’ (2018) 66(2) *UCLA Law Review* 35 et seq.

¹²⁴⁴ Ibid.

¹²⁴⁵ In the US, the disclosure requirement under § 112(a) is similar to Article 83 EPC and concerns only the invention, and not the inventive process. (35 US Code § 112; both Art. 83 EPC and 35 USC § 112(a) are aligned with Article 29 TRIPS).

¹²⁴⁶ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 37.

¹²⁴⁷ However, misrepresentations or omissions must be “material” to constitute inequitable conduct or fraud. Information is not “material” if it has no rational relationship to a decision a patent examiner must make, whether on the patentability of a claimed invention or on any other matter (Tabrez Y Ebrahim, ‘Artificial Intelligence Inventions & Patent Disclosure’ (2020) 125(1) *Penn State Law Review* 2023; William Samore, ‘Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?’ in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018) 478).

¹²⁴⁸ Moreover, the Patent Act includes a provision that is prima facie incompatible with the mandatory disclosure of the inventive process. The last sentence of Section 103 states that “patentability shall not be negated by the

whether information on the use of AI in the invention process is material to patentability.¹²⁴⁹ Assuming that AI is a tool in the hands of the person skilled in the art, it is hard to see how any information on the use of AI in the inventive process could affect the patentability since patentability shall not be negated by the manner in which the invention was made. Also, the mere omission of information on the inventive process should not qualify as “affirmative egregious misconduct”. This might change in case of truly AI-related inventions, where the disclosure of the “real” inventor could be warranted for “candour” purposes.¹²⁵⁰ Moreover, the implementation of such a disclosure requirement could have unintended consequences. For example, it could discourage inventors from using AI or machine learning technology in their inventive process, out of fear of having to disclose it and potentially weakening the patent’s validity or enforceability. This would be particularly problematic in fields where the use of AI or machine learning is becoming increasingly common, such as pharmaceuticals and biotechnology. As a result, the disclosure requirement could stifle innovation in these fields and harm their progress.

Overall, the proposed reforms would enhance transparency regarding the role of AI in the production of inventions and enable recalibration of examination practices accordingly.¹²⁵¹ This means that patent applicants should be required to disclose the role of any AI-driven system in devising the subject matter, in a manner that allows for an adequate patentability assessment.¹²⁵²

f) Against an “Inventive Process” Disclosure Obligation

While requiring the disclosure of the inventive process could enhance the understanding of AI-related patent applications, particularly in assessing the inventive step, implementing and enforcing such a requirement may prove challenging. This difficulty is especially pronounced in cases where the inventive process is complex or difficult to articulate.¹²⁵³ Consequently, the

manner in which the invention was made”. This provision emphasizes that the proper inquiry is not what the particular inventor did to develop the invention, but rather what the PHOSITA would have been required to do to develop the invention.

¹²⁴⁹ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 37.

¹²⁵⁰ In a 2020 USPTO Patent Public Advisory Committee Meeting, Coke Stewart proposed that the duty of candor rules should not be affected by the use of AI as long as it remains a tool in the view of the USPTO, since the Office has not observed AI machines spontaneously inventing (USPTO, Patent Public Advisory Committee Meeting Quarterly Meeting (2020) 167-169, www.uspto.gov/sites/default/files/documents/PPAC_Transcript_20200206.pdf).

¹²⁵¹ Eva Stanková, ‘Human Inventorship in European Patent Law’ (2021) 80 *The Cambridge Law Journal* 23.

¹²⁵² Ibid.

¹²⁵³ The new disclosure requirement regarding the inventive process may go against the TRIPS obligations of EU and EPC Member States. This could be the case if it were seen as a major patentability requirement, as TRIPS specifies that patents must be available for new inventions that involve an inventive step and are capable of industrial application. Additionally, TRIPS only requires the applicant to disclose the invention, not the inventive process. The proposed disclosure requirements may also violate the principle of technological neutrality in TRIPS, which states that patents should be available without discrimination based on the field of technology. This could be the case if the requirements disproportionately increase the patentability standard in specific industries, like pharmaceuticals, without legitimate reasons. However, since the TRIPS system allows for flexibility, it is difficult to discuss these hypothetical scenarios (see: Henning G Ruse-Khan and Roberto Romandini, ‘Patentability of Pharmaceutical Inventions Under TRIPS: Domestic Court Practice as a Test for International Policy Space’ (2016) MPI Research Paper No 16-02 <https://ssrn.com/abstract=2736224>; Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 34-35).

practical utility of this disclosure requirement remains uncertain. In line with this, the following reasons are also against a disclosure requirement.

If an AI system can produce effective solutions rapidly, there may be insufficient time for detailed disclosures that would typically be required under patent law. In scenarios where AI tools can swiftly address urgent global challenges, such as health crises or environmental issues, the emphasis on understanding the underlying mechanics may seem less critical.¹²⁵⁴ This raises questions about whether strict adherence to disclosure requirements might hinder timely access to potentially life-saving technologies. To navigate these challenges, one approach could involve relaxing disclosure requirements for inventions intended for rapid public deployment, opt for an adapted utility model (see Section G.I.d) or an “expedited patent examination” (see Section G.I.b). In cases where immediate application is paramount, a balance might be struck between ensuring some level of accountability and allowing for expedited access to innovative solutions.

Additionally, if the scope of the disclosure requirement is intended to provide more information on the use of AI in research and development, it may be unnecessary since patent applications are not the sole source of information regarding the inventive process. Scientific publications, news articles, and any publicly available information can be used by the EPO and third parties to evaluate the inventive step. Therefore, it should be possible to establish a skilled person as proficient in specific AI techniques without obligating inventors to disclose their individual inventive process. Additionally, patent applications are considered advanced technical knowledge and are not part of the general knowledge of a skilled person. Consequently, they are not the most reliable reference documents for assessing typical research tools.¹²⁵⁵

Enforcing such rules would require examiners and third parties to gather evidence that the applicant did not fully or correctly disclose their inventive process. However, this could be challenging, as it may not be possible to reverse-engineer the invention from the information provided in the application, and there may not be enough publicly available information or insider knowledge to gather sufficient evidence.¹²⁵⁶ Moreover, under the current EPC, patent applications cannot be rejected solely because the applicant was dishonest or deceitful during the prosecution process, as long as this does not affect the substantive patentability requirements.¹²⁵⁷ Therefore, national courts can only revoke a European patent based on the grounds set out in Article 138 EPC, which does not include false or misleading statements made by the applicant to the EPO.¹²⁵⁸

Patent offices may be able to use AI themselves to verify sufficient disclosure in patent applications, but it is unclear whether this would be necessary or advisable.¹²⁵⁹ There may be

¹²⁵⁴ Ibid.

¹²⁵⁵ Tommaso G Trabucco, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021) 34.

¹²⁵⁶ Ibid, 33.

¹²⁵⁷ Alexandra Hoss, *Deceptive Conducts before the Patent Office: Challenges for Patent Law and Competition Law* (Baden-Baden 2019) 302 et seq.

¹²⁵⁸ Ibid, 86-87; Article 138 EPC.

¹²⁵⁹ EPO, ‘Legal aspects of patenting inventions involving artificial intelligence (AI): Summary of feedback by EPC contracting states’ (20 February 2019) <https://www.epo.org/news-events/news/2019/20190220.html>; Department of Commerce, Patent and Trademark Office, ‘Request for Comments on Patenting Artificial

certain types of inventions that pose problems for sufficient disclosure, but these issues are not specific to AI-related inventions. For example, certain process claims, or pharmaceutical inventions may be difficult to disclose clearly and completely. Also, there may be a need to disclose the process of generating a trained model or the specifics of a learning model. This may necessitate a review of the sufficiency of disclosure standard to strike a balance between transparency and disclosure in AI technology.¹²⁶⁰

One proposed solution is to use dataset deposition to address AI uncertainty (see Section F.I.2.c).¹²⁶¹ However, this approach would require a deeper understanding of the software involved when assessing a patent in dispute, potentially complicating the claims analysis process.¹²⁶² While there may be a need to include a machine perspective in patent law in the future, for now, it is reasonable to maintain the current standard to avoid risking excluding human inventors from the patent system.¹²⁶³ Furthermore, the current patent laws in Europe already provide mechanisms for assessing the patentability of AI-related inventions. As mentioned earlier, the non-obviousness requirement takes into account the level of ordinary skill in the art, including the level of technological advancement, which would include the use of AI or machine learning technology.

Therefore, while some applicants disclose in the description the fact that they have created an invention based on the AI estimation, there are other cases where applicants do not disclose the use of AI, though they actually did use it. It is difficult for third parties to discern which invention was created with the aid of AI. While some scholars have addressed this issue by imposing on applicants a duty to disclose the use of AI, this disclosure should not play a role in the examination of the inventing step, meaning that the examinations and especially the person skilled in the art should be the same for inventions that have disclosed the use of AI as the ones that have not. Once the person skilled in the art is determined, the level of the applicants does not matter in examining the inventive step. So long as the person skilled in the art is expected to use AI, the inventive step should be examined on the premise of a person skilled in the art with AI, regardless of whether the applicants use AI or not. It is not the applicants, but the person skilled in the art who determines the level of the inventive step.

Intelligence Inventions' (2019) 84 Federal Register 44889; WIPO, Standing Committee on the Law of Patents, 'Background Document on Patents and Emerging Technologies' (28 May 2019) SCP/30/5, § 67 et seq.; Christian Heinze and Andreas Engel, 'KI und Patentrecht' in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 64 et seq.

¹²⁶⁰ Ryuta Hirashima, 'New Issues in patent law brought about by inventions related to machine learning and deep learning' (2020) 23 *PATENT* 163 et seq.

¹²⁶¹ Dan L Burk, 'AI Patents and the Self-Assembling Machine' (2021) 105 *Minnesota Law Review Headnotes* 313; Tabrez Y Ebrahim, 'Artificial Intelligence Inventions & Patent Disclosure' (2020) 125(1) *Penn State Law Review* 147-151.

¹²⁶² Etsuko Yoshida, 'Artificial Intelligence-Related Invention in Japan and Its Disclosure With a Focus on Human Intervention' in Alexandra Mendoza-Caminade (ed), *L'entreprise Et l'intelligence Artificielle - Les réponses du droit* (Presses de l'Université Toulouse Capitole 2022) 225 et seq.

¹²⁶³ Martin Stierle, 'A De Lege Ferenda Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System' (2021) *GRUR International* 128.

3. Preliminary Results

The sufficiency of disclosure is a core requirement for patentability under the EPC, mandating that an invention must be disclosed with enough detail and clarity for a person skilled in the art to reproduce it without undue burden. Article 83 EPC stipulates this requirement, which is technologically neutral and applies to all types of inventions. The description must focus on essential features and avoid unnecessary details, also related to AI and datasets, especially in rapidly advancing fields like AI. The EPO's problem-and-solution approach further guides the assessment of sufficiency by linking the inventive step to the disclosed problem and its solution, ensuring that patents are not granted based on *ex post facto* analysis.

The question arises on whether patent applicants should be required to disclose the AI tools and processes used in their inventive processes.

Opponents argue that such a requirement could be overly burdensome and difficult to enforce, given the opacity and complexity of AI systems. Additionally, they contend that current patent laws already provide sufficient mechanisms for assessing patentability without needing to disclose the inventive process. It is likely that some applicants will explicitly disclose in their descriptions that their invention was created using AI, while others will not, even when AI was indeed used. This inconsistency makes it challenging for third parties to determine which inventions were AI-related, leading to a lack of transparency in the patent landscape. Consequently, the examination process, particularly the assessment by the person skilled in the art, should remain consistent for inventions regardless of whether AI use is disclosed. Once the person skilled in the art is established, the applicant's own level of expertise becomes irrelevant to the inventive step analysis. If the person skilled in the art is expected to utilize AI tools, then the inventive step should be assessed based on a skilled person equipped with AI, irrespective of whether the applicants themselves employed AI. This focus on the perspective of the person skilled in the art ensures that evaluations are uniform and fair, promoting clarity and reducing ambiguity in understanding how an invention achieves its claimed effects.

Proponents, however, suggest that as AI becomes more integral to innovation, it may be necessary to adjust disclosure standards to ensure transparency and prevent the unjust grant of patents for AI-related inventions. Various theories favouring the disclosure of AI processes, including proposals to amend Rule 42 Implementing Regulations of the EPC to require detailed disclosure of AI systems used in the invention process have been elaborated. Proposed amendments include requiring detailed descriptions of AI systems, including training data, algorithms, and outputs, to ensure that the disclosure is sufficiently clear and complete for a skilled person to replicate the invention.

II. The Approach at the EPO

1. EPO's Guidelines

The revised EPO Guidelines of 2025 state that where the technical effect of an invention is contingent upon specific features of the training data employed, those features must be sufficiently disclosed to enable the skilled person to reproduce the effect, unless such features can be identified without undue effort on the basis of common general knowledge.¹²⁶⁴ The disclosure is therefore insufficient, when the skilled person is not able to reproduce the technical effect without undue burden using common general knowledge over the whole scope of the claim.¹²⁶⁵ This highlights that any characteristics of the training dataset essential for replicating the claimed technical effect in a patent must be disclosed, unless they can be easily derived by a skilled person without significant effort.¹²⁶⁶ Nevertheless, according to the EPO Guidelines it is generally not necessary to provide the actual training dataset itself (see also F-III, 3 and G-VII, 5.2).¹²⁶⁷

This revision followed nearly four years after the BoA decision in T 161/18,¹²⁶⁸ which had already established that a failure to disclose key aspects of training data could lead to a finding of insufficiency under Article 83 EPC.¹²⁶⁹ In that case, a method for determining cardiac output using an artificial neural network was deemed insufficiently disclosed because it lacked specific parameters or examples of input data necessary for training the network.¹²⁷⁰ The BoA found that the application lacked sufficient disclosure regarding the training data and process, rendering the invention non-reproducible by a skilled person and thus insufficient under Article 83 EPC.¹²⁷¹

In decision T 1669/21, the BoA addressed the sufficiency of disclosure under Article 83 EPC.¹²⁷² The patent in question referred broadly to a “calculation model” based on operational data but lacked technical detail concerning the model type, training methodology, and input

¹²⁶⁴ Harry Bedford, ‘EPO Practice Update: Disclosure Requirements for AI Patent Applications’ (Solve Intelligence, 6 November 2024) <https://www.solveintelligence.com/blog/post/epo-practice-update-disclosure-requirements-for-ai-patent-applications>.

¹²⁶⁵ EPO Guidelines 2025, Part F-III, 3.

¹²⁶⁶ Ibid.

¹²⁶⁷ EPO Guidelines 2025, Part F-III, 3 and G-VII, 5.2.

¹²⁶⁸ EPO, T 161/18, 12 May 2020 (*Äquivalenter Aortendruck/ARC SEIBERSDORF*).

¹²⁶⁹ Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* 838; Julian Asquith, ‘AI Inventions and Sufficiency at the EPO’ (Marks & Clerk, 17 December 2020) <https://www.marks-clerk.com/insights/articles/ai-inventions-and-sufficiency-at-the-epo/>.

¹²⁷⁰ Ibid.

¹²⁷¹ Academic commentary supports this stringent approach. For instance, *Dhenne* notes that the decision in T 0161/18 highlights the necessity for applicants to provide adequate details about the training data and process to meet sufficiency requirements (Matthieu Dhenne, ‘T 161/18: Sufficiency of Disclosure Put to the Test of Artificial Intelligence’ (Institut Boufflers, 4 September 2020) <https://www.institutboufflers.org/en/t-161-18-sufficiency-of-disclosure-put-to-the-test-of-artificial-intelligence-matthieu-dhenne/>; Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* 838).

¹²⁷² EPO, T 1669/21, 23 July 2024; Christoph Hewel, ‘Navigating AI Patents Under Art. 83 EPC: Lessons from EPO Decision T 1669/21 on Sufficient Disclosure and Blackbox AI Protection’ (Paustian & Partner, 1 December 2024) <https://www.paustian.de/navigating-ai-patents-under-art-83-epc-lessons-from-epo-decision-t-1669-21-on-sufficient-disclosure-and-blackbox-ai-protection/>.

data.¹²⁷³ The Board held that such vagueness made the disclosure insufficient, as the skilled person would not be able to reproduce the invention without undue burden.¹²⁷⁴ Despite the patentee’s argument that general machine learning knowledge would enable implementation, the Board rejected this, emphasizing that references to concepts like “regression analysis” and “adapted calculation model” were too vague. The claim’s broad language and absence of guidance rendered the model scope indeterminate. Both analytical and machine learning approaches could fall within the claim’s ambit, but neither was sufficiently described.¹²⁷⁵ The Board further rejected the idea that the adaptability of machine learning negates the need for detailed disclosure. It stated that the wide variability in model architectures and data handling practices requires specific guidance, especially in complex industrial contexts. The use of generic AI terminology and reliance on standard tools or libraries did not meet the sufficiency standard without a defined model structure or example.¹²⁷⁶ Another issue concerned the training data. The patentee argued that data could be drawn from routine operations and that machine learning would inherently prioritise relevant variables. The Board disagreed, finding no description of the training data’s quantity, variety, or relevant features.¹²⁷⁷ Without such information, the skilled person would lack the necessary foundation to train an effective model. Finally, the absence of a reproducible embodiment contributed to the Board’s conclusion. While the patentee claimed that specifying one example would unduly narrow the invention, the Board held that an enabling example is essential, even in AI patents, to demonstrate feasibility. The lack of such an example left the invention too speculative, failing to meet the requirements of Article 83 EPC.¹²⁷⁸

The outcome of T 1669/21 holds broader implications for the drafting of patent applications in the AI domain.¹²⁷⁹ It illustrates that when claims involve AI methods, it is essential to indicate the use of such methods clearly and specifically, rather than relying on abstract references to computational models. Furthermore, the description must thoroughly outline the AI model,

¹²⁷³ This case arose from an appeal by the patent proprietor against the Opposition Division’s decision to revoke a patent concerning a method for assessing the condition of a vessel’s refractory lining using a computational model. Claim 1 of the contested patent referred to the creation of such a model based on various types of data, including care and production data, wall thicknesses, and process parameters, whereby the model was intended to process this information through computations and analysis. The central issue in the appeal was whether the patent disclosed the computational model with sufficient detail to enable a skilled person to carry out the invention without undue burden, as required by Article 83 EPC. The Board upheld the revocation, concluding that the patent did not meet the sufficiency standard (see: Christoph Hewel, ‘Navigating AI Patents Under Art. 83 EPC: Lessons from EPO Decision T 1669/21 on Sufficient Disclosure and Blackbox AI Protection’ (Paustian & Partner, 1 December 2024) <https://www.paustian.de/navigating-ai-patents-under-art-83-epc-lessons-from-epo-decision-t-1669-21-on-sufficient-disclosure-and-blackbox-ai-protection/>).

¹²⁷⁴ John Leeming, ‘Review of EPO software decisions in 2024’ (J A Kemp, 5 March 2025) https://www.jakemp.com/knowledge-hub/review-of-epo-software-decisions-in-2024/?utm_source=chatgpt.com.

¹²⁷⁵ Christoph Hewel, ‘Navigating AI Patents Under Art. 83 EPC: Lessons from EPO Decision T 1669/21 on Sufficient Disclosure and Blackbox AI Protection’ (Paustian & Partner, 1 December 2024) <https://www.paustian.de/navigating-ai-patents-under-art-83-epc-lessons-from-epo-decision-t-1669-21-on-sufficient-disclosure-and-blackbox-ai-protection/>.

¹²⁷⁶ Christoph Hewel, ‘Navigating AI Patents Under Art. 83 EPC: Lessons from EPO Decision T 1669/21 on Sufficient Disclosure and Blackbox AI Protection’ (Paustian & Partner, 1 December 2024) <https://www.paustian.de/navigating-ai-patents-under-art-83-epc-lessons-from-epo-decision-t-1669-21-on-sufficient-disclosure-and-blackbox-ai-protection/>.

¹²⁷⁷ John Leeming, ‘Review of EPO software decisions in 2024’ (J A Kemp, 5 March 2025) https://www.jakemp.com/knowledge-hub/review-of-epo-software-decisions-in-2024/?utm_source=chatgpt.com.

¹²⁷⁸ Ibid.

¹²⁷⁹ EPO, T 1669/21, 23 July 2024.

including its type, architecture, and internal structure, where applicable. The specification should also describe the training dataset in sufficient detail, explaining its nature, relevance, and preparation process, so that the model's operation becomes reproducible. A general reference to the existence of data or tools is unlikely to suffice. Importantly, the claims should clearly define the input and output variables in concrete terms, rather than listing a wide array of possible data types that the skilled person must filter and select independently.

2. Strengthening the EPO's Approach to AI Disclosures *de Lege Lata*

While the EPO has taken initial steps to accommodate the particularities of disclosure for AI-related inventions, further updates to the Guidelines are needed to align examination practices with both legal requirements and technological realities.

The updated Guidelines still do not incorporate the guidance from further Article 83 EPC case law and the corresponding information that if not disclosed could result in insufficiency of disclosure under Article 83 EPC. Decisions such as T 1539/20,¹²⁸⁰ T 606/21,¹²⁸¹ and T 1526/20¹²⁸² emphasise that AI-related inventions may require disclosure of the model's architecture, training methodology, representative datasets, validation data (T 1191/19)¹²⁸³, and at least one dataset capable of solving the technical problem (T 161/18,¹²⁸⁴ T 1191/19).¹²⁸⁵ While the Guidelines acknowledge that a technical effect must be achievable across the entire scope of the claims, they fail to capture the BoA's concern that without such information, the patent specification risks becoming a speculative research proposal rather than an enabling disclosure (T 1526/20).¹²⁸⁶

The EPO's current position, that the dataset itself need not be disclosed, must be interpreted in light of the requirement that all essential characteristics enabling reproduction of the technical effect must be disclosed, unless derivable through general knowledge without undue burden.

a) Options for Updates to the Guidelines

Suggestions for updates to the EPO Guidelines could be as follows:

1. If a technical effect relies on specific training data, the relevant characteristics of that data should be included in the application.¹²⁸⁷

¹²⁸⁰ EPO, T 1539/20, 24 November 2022 (*Performance monitoring/INETCO SYSTEMS*).

¹²⁸¹ EPO, T 606/21, 28 February 2023.

¹²⁸² EPO, 1526/20, 14 March 2023 (*Liveness testing/SAMSUNG*).

¹²⁸³ EPO, T 1191/19, 1 April 2022 (*Neuronal plasticity/INSTITUTGUTTMANN*).

¹²⁸⁴ EPO, T 161/18, 12 Mai 2020 (*Äquivalenter Aortendruck/ARC SEIBERSDORF*).

¹²⁸⁵ Mateo Aboy et al., 'The sufficiency of disclosure of AI inventions' (2024) 19(11) *JIPLP* 838; Julian Asquith, 'AI Inventions and Sufficiency at the EPO' (Marks & Clerk, 18 December 2020) <https://www.marks-clerk.com/insights/articles/ai-inventions-and-sufficiency-at-the-epo/>.

¹²⁸⁶ Mateo Aboy et al., 'The sufficiency of disclosure of AI inventions' (2024) 19(11) *JIPLP* 838.

¹²⁸⁷ These amendments also contribute to aligning AI disclosure requirements with those in the biotechnology field, suggesting a trend towards using Biotech Guidelines and related case law as frameworks for assessing AI

2. A patent application must disclose enough details to allow a skilled person to replicate the trained AI system. The AI must be specifically tailored to address the identified technical problem, rather than being described in general terms. Simply applying AI or machine learning to a specific domain or problem does not, in itself, provide a sufficient basis for patentability (see T 1191/19).¹²⁸⁸
3. Another option would be the adoption of an “AI disclosure checklist” to guide examiners in the assessment of sufficiency under Article 83 EPC. This checklist could prompt examiners to verify whether the specification includes (i) a description of the AI model’s architecture and (ii) a detailed account of the training methodology and at least one dataset suitable for achieving the claimed technical effect. If either of these elements is absent, the examiner could issue a *prima facie* objection under Article 83 EPC, thereby shifting the burden to the applicant to rebut the presumption of insufficiency. Such a mechanism would likely encourage applicants to pre-emptively include critical technical details, thereby improving examination efficiency, reducing prosecution time, and enhancing legal certainty.
4. While the Guidelines now caution that demonstrating a technical effect in most, but not all, scenarios may be insufficient, they omit another important aspect highlighted in case law: that disclosure standards analogous to those employed in scientific publishing may be suitable for AI training processes (T 1526/20).¹²⁸⁹ The EPO could draw from scientific reporting frameworks in the biomedical domain. For instance, the Consolidated Standards of Reporting Trials-Artificial Intelligence and the Minimum Information about Clinical Artificial Intelligence Modelling checklist, specify requirements regarding training data, model selection and optimisation, algorithmic performance, and the hardware and software environments in which the AI operates.¹²⁹⁰ These guidelines propose a tiered model of transparency, from full disclosure of source code and scripts (Tier 1) to no sharing of the underlying model or codebase (Tier 4).¹²⁹¹ Despite their relevance, the Guidelines do not currently address how such structured approaches might help ensure reproducibility where textual explanation alone is insufficient. Depending on the AI system’s context of use, sensitivity, and associated risk, the EPO may benefit from incorporating such calibrated disclosure standards into its examination framework.¹²⁹²
5. When considering prior art, patent documents are not particularly useful as they are intended to disclose the invention in a clear and complete manner, rather than the research and development process or tools used to arrive at the invention. Therefore, in the future the EPO could require a disclosure of the inventive process, which would include the steps taken to arrive at the invention.¹²⁹³

algorithms (Directive 98/44/EC of the European Parliament and of the Council of 6 July 1998 on the legal protection of biotechnological inventions).

¹²⁸⁸ Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* 838.

¹²⁸⁹ Matthew Chun, ‘Artificial Intelligence for Drug Discovery: A New Frontier for Patent Law’ (2024) 104 *JIPLP* 5; Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* 839.

¹²⁹⁰ Matthew Chun, ‘Artificial Intelligence for Drug Discovery: A New Frontier for Patent Law’ (2024) 104 *Journal of the Patent and Trademark Office Society* 5.

¹²⁹¹ *Ibid.*

¹²⁹² Mateo Aboy et al., ‘The sufficiency of disclosure of AI inventions’ (2024) 19(11) *JIPLP* 839.

¹²⁹³ EPO, ‘Comments by the European Patent Office, WIPO Conversation on Intellectual Property (IP) Artificial Intelligence (AI), Second Session July 7 to 9, 2020, Revised Issues Paper on Intellectual Property Policy and

6. The EPO could consider also incorporating illustrative examples and conducting a retrospective audit of granted patents in maturing AI subfields, where benchmarking datasets and performance metrics have already become standardised. Such steps could assist in calibrating future guidance on disclosure.
7. An alternative to revealing the training data could be to disclose the learned coefficients or weights of the model. Best practices for these disclosures will become clearer as more AI-related inventions are examined. This approach aligns with the technical BoA's findings in the T 161/18 case, which stated that inadequate information about AI training data could lead to insufficient disclosure of an invention.¹²⁹⁴
8. The EPO might consider procedural incentives to encourage thorough disclosure, for instance, accelerated examination or reduced maintenance fees could be offered to applicants who provide complete technical details, such as training data, model weights, or source code.¹²⁹⁵ Such incentives would not only promote stronger and more transparent patent filings, but also harmonise legal requirements with the fast-moving and often opaque nature of AI development.¹²⁹⁶

Adopting this standard in the Guidelines could enhance legal certainty and align EPO practice with disclosure norms in the AI research community.

b) Implementation of a Depository Requirements for AI Working Models

Furthermore, in response to the challenges posed by the opaque, non-deterministic nature of AI systems, some have proposed a depository obligation for AI working models,¹²⁹⁷ analogous to the deposit requirement for biological material under the Budapest Treaty.¹²⁹⁸ Under Rule 31 Implementing Regulations of the EPC, applicants may deposit biological material that cannot be fully described in the application. A similar system for AI could allow the deposit of trained model weights, representative training datasets, or executable model files. Access could be controlled under provisions similar to Rule 33 Implementing Regulations of the EPC, thereby balancing sufficiency with confidentiality. This would be particularly useful where textual disclosure is insufficient and could be modelled on access controls in the biological context to balance sufficiency with commercial sensitivity.

As proposed by *Yanisky-Ravid* and *Jin*, under this model, applicants would be required to submit a functioning version of the AI system (for example, source code, training data, and

Artificial Intelligence' (WIPO/IP/AI/2/GE/20/1 REV) 8 (stating that the EPC "does not contain any provisions which would prevent patenting certain subject-matter based on how or by whom it was generated").

¹²⁹⁴ EPO, T 161/18, 12 May 2020 (*Äquivalenter Aortendruck/ARC SEIBERSDORF*); Julian Asquith, 'AI Inventions and Sufficiency at the EPO' (Marks & Clerk, 18 December 2020) <https://www.marks-clerk.com/insights/articles/ai-inventions-and-sufficiency-at-the-epo/>.

¹²⁹⁵ Tabrez Y Ebrahim, 'Artificial Intelligence Inventions & Patent Disclosure' (2020) 125(1) *Penn State Law Rev* 147.

¹²⁹⁶ Mateo Aboy et al., 'The sufficiency of disclosure of AI inventions' (2024) 19(11) *JIPLP* 839-840.

¹²⁹⁷ Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 42-43.

¹²⁹⁸ Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure (Budapest, 28 April 1977, amended 26 September 1980) and Regulations, WIPO Publication No 277(E).

relevant outputs) alongside their patent application.¹²⁹⁹ This would not only facilitate the patent examiner's technical understanding but also enhance legal certainty in terms of disclosure and inventive step.

Proponents argue that such a mechanism would improve transparency by providing a demonstrable instance of how the AI system operates, which may compensate for the often vague or technically inadequate descriptions in AI-related patent applications. Depositing a working model could also assist in meeting the utility requirement, as it allows for a direct assessment of the invention's practical applicability. Examiners would be able to interact with the system rather than relying exclusively on written descriptions, which are frequently insufficient to fully convey the operational logic of modern AI.

However, this proposal raises two critical objections that require closer examination. First, unlike with biological deposits, the disclosure of an AI model entails significant confidentiality risks for the applicant. AI systems are typically general-purpose tools with applications extending far beyond the specific invention being claimed. Requiring the full deposit of such models could inadvertently expose commercially valuable trade secrets and exceed the conventional patent bargain, which traditionally mandates disclosure only of the concrete technical teaching of the invention at hand. The scope of disclosure would arguably extend beyond what is justified by the exclusivity granted. Second, the analogy to microorganisms is imperfect. In cases involving biological material, the rationale for deposit is the physical unavailability or descriptive inaccessibility of the subject matter. Deposit ensures that the invention can be reproduced, thereby meeting the sufficiency of disclosure requirement. In contrast, AI models, particularly those based on learning-based architectures, do not necessarily offer reproducibility in the conventional sense. Their outputs are often contingent on non-transparent internal states, random seeds, or evolving datasets. As such, even the provision of a complete model may not substitute for the explanatory clarity expected under patent law, nor can it guarantee functional replication. Consequently, the deposit of an AI model does not necessarily render the invention reproducible or intelligible in the same way that a biological sample might.

Despite these limitations, a tailored depository obligation could still serve important auxiliary purposes. It could function as evidentiary material in subsequent infringement proceedings, providing insight into the internal mechanics of the AI system.¹³⁰⁰ It could also address the insufficiency concerns raised when applicants fail to adequately explain how the invention solves the technical problem it claims to address. In this sense, the deposited model could assist in verifying the contribution of the AI to the invention and in demarcating the boundary between human and machine input, a matter of increasing relevance in patent law.

In conclusion, although the implementation of a depository rule for AI working models is conceptually appealing as a response to insufficient disclosure in AI-related patents, any such measure must carefully balance transparency interests with legitimate confidentiality concerns.

¹²⁹⁹ Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 42-43.

¹³⁰⁰ *Ibid*, 42.

Moreover, the analogy to existing microorganism depository systems is only partially persuasive given the fundamental differences in reproducibility and determinism. If introduced, the rule would require strict procedural safeguards and clear delineation of scope to ensure that it supports, rather than disrupts, the broader aims of the patent system.

3. A *De Lege Ferenda* Approach to Article 83 EPC and Rule 42(1)(c)

As previously described, the sufficiency of disclosure requirements for patent applications is governed by Article 83 EPC and Rule 42 of the Implementing Regulations to the EPC. However, the increasing complexity and rapid evolution of AI technologies present new challenges for applicants attempting to meet these requirements. Consequently, it may be necessary to amend the current EPC framework to offer more precise guidance or to introduce increased flexibility in the context of AI-related applications.

Article 83 EPC mandates that a patent application must disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.¹³⁰¹ Satisfying this requirement in the context of AI inventions is particularly demanding due to the technical and conceptual opacity often inherent in such systems. Therefore, it may be appropriate to consider updating this provision to provide explicit guidance on how sufficiency of disclosure should be assessed with respect to AI-related inventions. The current wording of Article 83, “the European patent application shall disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art”, is, in principle, technologically neutral.¹³⁰² Nevertheless, to enable a person skilled in the art (as developed into the concept of the “Skilled Person 2.0” in Section D.V.3) to implement the invention without undue experimentation, detailed information about the AI system, such as algorithms and training datasets, may be required. This has led to growing scrutiny over whether disclosures relating to AI satisfy the requirements of Article 83.

A *de lege ferenda* approach could contemplate the insertion of a new clause explicitly addressing AI-related inventions. Such an amendment might read: “[...] For AI-related inventions, the disclosure shall include the training data used, the algorithms employed, and the outputs generated. The disclosure must also list any technical advancements made possible by AI, such as increases in functionality, accuracy, or efficiency”. This would provide clearer direction to applicants seeking protection for AI inventions while maintaining the current disclosure standard for other technological fields.

However, the desirability of such an extensive and arguably burdensome disclosure obligation is not self-evident. The proposed expansion of Article 83 EPC and Rule 42 Implementing Regulations of the EPC is a logical consequence of supporting a model- and data-based disclosure requirement. Yet, it remains insufficiently justified whether such a far-reaching obligation, especially when the information disclosed may not be decisive for understanding the core of the invention, is truly beneficial or necessary. An overextended disclosure

¹³⁰¹ Article 83 EPC.

¹³⁰² Article 83 EPC.

requirement risks imposing disproportionate burdens on applicants and may even hinder innovation by compelling the release of proprietary technical details that are peripheral to the inventive concept.

Furthermore, Rule 42(1)(c) Implementing Regulations of the EPC currently requires that the description “disclose the invention, as claimed, in such terms that the technical problem, even if not expressly stated as such, and its solution can be understood, and state any advantageous effects of the invention with reference to the background art”.¹³⁰³ An updated version could read: “disclose the invention, as claimed, in such terms that the technical problem, even if not expressly stated as such, and its solution can be understood, including the AI algorithms or models used, and state any advantageous effects of the invention with reference to the background art. Any training data, pre-processing techniques, or post-processing techniques used to develop and operate the AI algorithms or models must likewise be fully disclosed in the description”.

Such an amendment would obligate applicants to disclose in detail all AI models and algorithms, the associated input and output data structures, and any relevant training, pre-processing, or post-processing methods. This would enable patent examiners to assess the technical contribution and reproducibility of the claimed invention more effectively. Nevertheless, this approach raises substantial concerns regarding conflicts with trade secret protection. Disclosing sensitive information, such as proprietary training datasets, may undermine competitive advantages and lead to the loss of confidentiality protections. Since trade secrets only retain their value if they remain undisclosed, imposing such obligations may deter applicants from pursuing patent protection altogether, favouring trade secrecy instead. This highlights the tension between legal certainty and transparency in patent law, on the one hand, and the preservation of commercial confidentiality, on the other.

4. Approaches to Disclosure for Category IV to V Inventions

For inventions falling within Categories IV and V the focus of legal protection and the corresponding disclosure obligations under the EPC must rest squarely on the inventive output, not the underlying AI systems themselves.

The requirements in Article 83 EPC need to apply regardless of whether the inventive process was human-led, AI-assisted, or AI-generated. The obligation does not extend to explaining the internal mechanisms of the AI system involved in the invention’s conception unless such mechanisms are part of the claimed technical teaching.¹³⁰⁴ The decisive question is whether the skilled person can reproduce the invention based on the disclosure, not whether the applicant has described the method by which the invention was devised. Similarly, for the assessment of inventive step under the problem-solution approach, the EPO evaluates whether the claimed solution would have been obvious to a person skilled in the art, equipped with common general knowledge and, where appropriate, access to AI systems as tools. The technical merit of the claimed subject matter is what determines its patentability. Thus, the inventive contribution

¹³⁰³ Rule 42(1)(c) Implementing Regulations of the EPC.

¹³⁰⁴ EPO Guidelines F-III, 1; Article 83 EPC.

must be appraised independently of the inventive process and judged solely on the basis of the disclosed technical teaching.

Under Article 84 EPC, clarity is assessed separately from sufficiency of disclosure, although these requirements may overlap in practice. As established in decision T 2574/16, a lack of clarity that permeates the entire scope of the claim may give rise to objections under both Articles 83 and 84 EPC.¹³⁰⁵ This is particularly pertinent for AI-related inventions, where claim elements may reflect abstract concepts, probabilistic models, or otherwise non-deterministic behaviours that risk introducing ambiguity. Accordingly, applicants must ensure that the claims are drafted with precision and that any AI-related terminology is defined and substantiated in the description.

While the use of AI may play a significant role in the development of an invention, the legal assessment under the EPC focuses exclusively on the reproducibility and clarity of the claimed invention. The internal functioning of the AI system involved in the ideation or optimisation process is not, in itself, the subject of protection, unless it forms part of the claimed technical teaching. Applicants must therefore avoid conflating the protection of AI systems with the protection of the inventive outputs they generate, and instead concentrate their disclosures and claims on the latter.

5. Suggestions for Patentees and Opponents

The EPO's stance appears to be that, although it is not mandatory to disclose the specific training dataset, the description of the training dataset must be sufficiently detailed and technically substantiated.¹³⁰⁶ They emphasise the need to disclose technical effects and specify the circumstances under which details about associated training data are necessary to reproduce those effects.¹³⁰⁷ Accordingly, the primary objective is to allow a person skilled in the art to reproduce the inventive output, not to understand or replicate the AI system in its entirety, unless the AI itself is the claimed subject matter, which is not the case in Categories IV and V.¹³⁰⁸

Given the centrality of technical contribution to the EPO's inventive step assessment, it is essential that all relevant technical aspects be explained in a detailed and structured manner.¹³⁰⁹ This may include elements such as model architecture, training methodology, and any defining

¹³⁰⁵ Jochen Ehlers et al., 'European Patent Office', in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 112.

¹³⁰⁶ Caleb Gilliam-Scott, 'Updated EPO Guidelines Impact AI Disclosure' (Pearl Cohen 2024).

¹³⁰⁷ Ibid.

¹³⁰⁸ This aligns with the previously discussed decision in T 161/18, where the BoA found that the disclosure of an AI-based invention was insufficient when the training data or specific parameters of the neural network were not adequately described. Without this information, the skilled person cannot carry out the invention, leading to a violation of Article 83 EPC.

¹³⁰⁹ Jochen Ehlers et al., 'European Patent Office', in Jonathan P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 118.

traits of the training data or the dataset, but only insofar as these are necessary to render the output technically plausible and reproducible. A recurring challenge lies in the imbalance between extensive descriptions of the AI system and insufficient elucidation of the inventive result it produces. This often results in difficulties for examiners in assessing inventive step and sufficiency, as the causal link between AI processing and the claimed technical effect remains underdeveloped.

To meet these requirements, patent claims must be carefully formulated to include all technical features essential to the functioning of the invention. These features should be presented in a way that reflects their contribution to solving a clearly derivable technical problem. Even when the invention addresses a non-technical problem, this may be reformulated as a technical challenge, provided that the associated benefits are framed as technical effects. Moreover, non-technical aspects of the invention should only be included in the claims if they are structurally or functionally linked to technical features, thereby supporting their contribution to the technical character.

Applicants should adopt practical strategies to enhance the clarity and reproducibility of their inventions. These include providing a schematic or diagrammatic representation of the AI model, offering a detailed account of any novel components, and supplying at least one illustrative example that pairs input data with its corresponding output.¹³¹⁰ Crucially, applicants must evaluate what level of disclosure regarding the training data is required for the invention to be reproducible across the entire scope of the claims. This may involve describing the training process, or referencing learned model parameters such as weights or coefficients, where applicable.¹³¹¹

Although some practitioners may draw an analogy with biological sequence listings, suggesting that full disclosure of training datasets could pre-empt sufficiency objections, this is generally impractical in the AI domain due to the vast size and proprietary nature of training data. Moreover, datasets often constitute protectable subject matter under regimes such as the *sui generis* database right, and their disclosure could undermine commercially sensitive assets.¹³¹²

The plausibility standard is a critical element of the EPO's legal framework, particularly in relation to sufficiency and inventive step. If a technical effect is central to the problem the invention purports to solve, it must be plausible at the time of filing, even if not explicitly mentioned in the claims.¹³¹³ While post-published evidence may be admissible to confirm a technical effect, such evidence is only considered if the original application renders the effect plausible.¹³¹⁴ This requirement serves to prevent speculative claims and to ensure that protection is not granted for inventions that are insufficiently developed at the time of filing.

¹³¹⁰ Eden Winlow, 'Patentability of AI Inventions: Updates to the EPO Guidelines for Examination' (Bristows 2024).

¹³¹¹ Ibid.

¹³¹² Caleb Gilliam-Scott, 'Updated EPO Guidelines Impact AI Disclosure' (Pearl Cohen 2024).

¹³¹³ EPO Guidelines 2025, Part F-III, 12.

¹³¹⁴ An illustrative instance questioning this concept emerges in the case of T 2371/13, specifically concerning the reformulation of the technical problem within the context of assessing inventive step (EPO, T 2371/13, 4 July 2017 (*Association de deux colorants cationiques v L'OREAL*); EPO Guidelines 2025, Part G-VII, 5.2 and 11).

To that end, the EPO applies a two-part test: first, whether the invention makes a technical contribution; and second, whether this contribution is plausibly realisable across the claim's full scope.

In light of these considerations, applicants are advised to disclose the nature of the AI system employed, the characteristics of the dataset, and performance-related metrics where relevant. They should ensure that the disclosed information supports the plausibility of the invention's technical effect over the entirety of the claimed subject matter, which may necessitate further testing or experimental substantiation.

6. Preliminary Results

The 2025 revision of the EPO Guidelines clarifies that where a claimed technical effect depends on specific aspects of training data, those aspects must be disclosed unless derivable by the skilled person without undue effort. This aligns with established jurisprudence, notably T 161/18, where insufficient detail regarding the training process rendered the claimed invention irreproducible. In T 1669/21, the Board reiterated that general references to machine learning techniques or datasets, absent substantive technical detail, are inadequate under Article 83 EPC. The decision stressed the necessity of disclosing model architecture, training methodology, and at least one illustrative embodiment to ensure reproducibility.

Although the Guidelines have begun to address the unique disclosure challenges posed by AI-related inventions, further refinements are warranted. Relevant case law, such as T 1526/20 and T 1191/19, suggests the need for greater clarity concerning model structure, data characteristics, and performance validation. Proposals for improvement include the adoption of an AI-specific disclosure checklist, integration of scientific reporting standards, and procedural incentives for enhanced transparency. More radical suggestions involve the establishment of a depository system for trained models, analogous to biological deposits under the Budapest Treaty, though such proposals must navigate concerns around confidentiality and the non-deterministic nature of AI systems.

A possible *de lege ferenda* amendment to Article 83 EPC and Rule 42(1)(c) Implementing Regulations of the EPC could introduce AI-specific disclosure obligations, requiring detailed information on training data, model architecture, and processing techniques. Nonetheless, imposing such requirements raises concerns regarding proportionality and the potential conflict with trade secret protections. For AI-generated inventions (Categories IV and V), the sufficiency of disclosure remains focused on the technical teaching of the claimed invention rather than the AI system that contributed to its development.

Finally, applicants are encouraged to include detailed and structured descriptions of AI-related components only to the extent that they are essential for reproducing the claimed technical effect. Particular attention should be paid to demonstrating plausibility and ensuring that the invention can be carried out across the entire claim scope. While full disclosure of datasets is

generally impractical, sufficient technical context must be provided to meet the standards of Article 83 EPC.

G. PROPOSALS FOR A REVISED PATENT FRAMEWORK

I. Changes to the Patent System for AI-Related Inventions

1. A Sole (Adapted) Patent System

From the perspective presented in this work, patent protection for AI-related inventions appears desirable. As mentioned throughout this work, this thesis is in favour of enhancing the existing patent framework and adapt it to AI-related inventions. A new protection regime for AI-related output seems unnecessary at the current state of technology.¹³¹⁵

Still, some scholars believe that differentiated systems would be necessary to accommodate modern technologies.¹³¹⁶ They believe that a *sui generis* right could be designed with flexibility in mind, allowing it to evolve alongside technological advancements. A *sui generis* system would stand as distinct entities rather than mere extensions of the current patent framework.¹³¹⁷ They sustain that AI changes the landscape of inventions and an intellectual property law tailored to this new context is needed to serve the public good effectively.¹³¹⁸ *Meitinger*, for example, proposes to replace the current patent system with an innovation protection system that focuses on the actual product or service offered on the market, as opposed to the invention itself.¹³¹⁹ This idea suggests that the creation of inventions is no longer society's concern since AI systems generate inventions. The proposed system emphasizes protecting market-ready products and services. This shift implies that the legal framework would prioritize user experience and market viability over the inventive process itself.¹³²⁰ Thus, while *Meitinger's* proposal may seem attractive by simplifying the protection of inventions, it poses significant risks to the foundational principles of knowledge sharing, international cooperation in patent

¹³¹⁵ Josef Drexl et al., 'Position Statement on IP Law and Artificial Intelligence' (MPI Research Paper No. 21-10, 9 April 2021) 5.

¹³¹⁶ On the different approaches see: Martin Senftleben and Laurens Buijtelaar, 'Robot Creativity: An Incentive-Based Neighbouring Rights Approach' (2020) 42(12) *European Intellectual Property Review* 819 et seq.; Ana Ramalho, 'Will robots rule the (artistic) world? A proposed model for the legal status of creations by artificial intelligence systems' (2017) 21(1) *Journal of Internet Law* 16; Stefan Papastefanou, 'KI-gestützte Schöpfungsprozesse im geistigen Eigentum' (2020) *Wettbewerb in Recht und Praxis* 647. For parallel reflections in patent law, see Roman Konertz and Raoul Schönhof, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht?' (2018) *Zeitschrift für geistiges Eigentum* 411; AIPPI German Delegation, 'Copyright in artificially generated works' (2019) 18 et seq., <https://aippi.soutron.net/Portal/Default/en-GB/RecordView/Index/254>; Michael Abramowicz, 'Orphan Business Models: Toward a New Form of Intellectual Property' (2010) 124 *Harvard Law Review* 1406.

¹³¹⁷ Guido Noto La Diega, 'Associate Professor Guido Noto La Diega's Comments on WIPO's "Draft Issues Paper on Intellectual Property and Artificial Intelligence"' (WIPO/IP/AI/2/GE/20/1)' (2019) 7.

¹³¹⁸ Josef Drexl et al., 'Position Statement on IP Law and Artificial Intelligence' (MPI Research Paper No. 21-10, 9 April 2021) 23.

¹³¹⁹ Thomas H Meitinger, 'Künstliche Intelligenz als Erfinder?' (2020) *Mitteilungen der deutschen Patentanwälte* 49, 50 et seq.; Hermann Kronz, 'Patentschutz für die Innovation. Ein Modell' (1976) *Mitteilungen der deutschen Patentanwälte* 178 et seq.; Hermann Kronz, 'Innovationspatentschutz - ein Instrument der Wirtschaftspolitik' (1983) *Mitteilungen der deutschen Patentanwälte* 128 et seq.; Hermann Kronz, 'Patentschutz für die Innovation. Ein Modell' (1976) *Mitteilungen der deutschen Patentanwälte* 206; Hermann Kronz, 'Response in Defence of the Innovation Patent Concept' in William Kingston (ed), *Direct Protection of Innovation* (Berlin and Heidelberg 1987) 257; Ted Sichelman, 'Commercializing Patents' (2010) 62 *Stanford Law Review* 341.

¹³²⁰ Martin Stierle, *Das nicht-praktizierte Patent* (Tübingen 2018) 422 et seq.

law, and the overall incentive structure driving technological progress. The current patent system not only incentivizes investment in invention but also fosters an environment where knowledge is shared openly, an essential aspect for societal advancement in technology.

Still, scholars as for example *Picht* state that the introduction of novel *sui generis* rights for AI-related output appears unwarranted. The present state of research insights and market dynamics do not present a compelling case for the establishment of new *sui generis* rights, encompassing neighbouring rights, tailored for innovative AI-related content.¹³²¹ Along the same lines, other scholars express scepticism concerning the establishment of novel intellectual property rights for inventions generated by AI.¹³²² These scholars advise against overestimating AI's inventive capabilities and caution against conflating their aptitude for learning or automated output generation with genuine inventiveness.¹³²³ Additionally, creating a *sui generis* right for AI-related inventions could inadvertently disrupt the innovation ecosystem, leading to decisions driven by expected intellectual property rights rather than efficient production of new technologies.¹³²⁴

Similarly, while acknowledging certain counterarguments, *de Rassenfosse et al.*, advocate for adapting the current patent framework to more explicitly accommodate AI-related inventions.¹³²⁵ They argue that patent law is concerned primarily with the inventive quality of a technological output, rather than the human cognitive process by which it was conceived.¹³²⁶ From this standpoint, the decisive factor should be whether AI-related outputs satisfy the established criteria of patentability.¹³²⁷ The demonstrated capacity of AI systems to produce outputs that arguably meet these criteria supports this view.¹³²⁸ Although denying patent-like protection to such outputs may not completely eliminate the incentive to develop inventive AI systems, it raises practical issues related to legal certainty, fairness in attributing rights, and the efficiency of the innovation system. This discussion centres not on extending the *substantive* scope of patentable subject matter, but rather on clarifying and potentially reforming the

¹³²¹ Peter G Picht, Valerie Brunner and Rena Schmid, 'Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action' (MPI Research Paper No. 22-08, 28 May 2022) 22 et seq.

¹³²² Yann Ménière and Heli Pihlajamaa, 'Künstliche Intelligenz in der Praxis des EPA' (2019) *GRUR* 332 et seq.; Daria Kim et al., 'Artificial Intelligence Systems as Inventors? A Position Statement of 7 September 2021 in view of the evolving case-law worldwide' (MPI Research Paper No. 21-20, 2021) 1 et seq.

¹³²³ Yann Ménière and Heli Pihlajamaa, 'Künstliche Intelligenz in der Praxis des EPA' (2019) *GRUR* 335; Daria Kim et al., 'Artificial Intelligence Systems as Inventors? A Position Statement of 7 September 2021 in view of the evolving case-law worldwide' (MPI Research Paper No. 21-20, 2021) 1 et seq.

¹³²⁴ Gaëtan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1465.

¹³²⁵ Ibid, 1455 et seq.; see also: Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1079 et seq.; Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law' (2018) 39 *Cardozo Law Review* 2215 et seq.; 'Workshop 3' (Center for Information Technology, Society, and Law (ITSL), University of Zurich) <https://www.cipco.uzh.ch/de/veranstaltungen/IP-KI/politische-rechtliche-Gestaltung.html>.

¹³²⁶ Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1083.

¹³²⁷ Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law' (2018) 39 *Cardozo Law Review* 2230 et seq.

¹³²⁸ Ryan Abbott, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1079 et seq.; Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law' (2018) 39 *Cardozo Law Review* 2220.

doctrinal and procedural aspects of patent law, particularly with respect to the requirement that a named human inventor be identified in all patent applications.¹³²⁹

As *Yanisky-Ravid* and *Liu* point out, implementing technology-specific instruments and differential rewards is considered impractical.¹³³⁰ Abolishing patent protection for AI-related inventions, based on the frequent argument that machines cannot receive incentives, fails to address the inherent “one-size-fits-all” problem in the patent system and does not focus on the inventiveness itself but rather on the inventive process.¹³³¹ Instead of abolishing patents, it is suggested that flexible legal tools, such as the skilled person or the patent practitioner, be reevaluated to allow the patent system to adapt to technological change. While differentiated rules may be undesirable in the abstract, the use of adaptable tools could provide a more practical solution to the challenges posed by AI-related inventions.¹³³²

The global patent system requires an internationally uniform understanding of the concept of the inventive step to accommodate AI-related inventions.¹³³³ It is advisable to re-evaluate and rely on flexible instruments already present in patent law, such as the person skilled in the art.¹³³⁴ An advanced AI assisting a person skilled in the art or conducting prior art searches could identify numerous improvements to existing technology as obvious or unearthing prior art from expansive online and foreign language databases that a human examiner might overlook.¹³³⁵ This heightened rigor could be advantageous in preventing the emergence of dense intellectual property thickets. AI has thus the potential to elevate the standards for patentable inventions, identifying improvements that might be considered obvious by advanced AI systems.¹³³⁶

¹³²⁹ P Bernt Hugenholtz and João P Quintais, ‘Copyright and Artificial Creation: Does EU Copyright Law Protect AI-Assisted Output?’ (2021) *IIC* 1190-1191; Peter G Picht and Florent Thouvenin, ‘AI and IP: Theory to Policy and Back Again – Policy and Research Recommendations at the Intersection of Artificial Intelligence and Intellectual Property’ (2023) *IIC* 916 et seq.

¹³³⁰ Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law’ (2018) 39 *Cardozo Law Review* 2260 et seq.

¹³³¹ Rosa M Ballardini, Kan He and Teemu Roos, ‘AI-Generated Content: Authorship and Inventorship in the Age of Artificial Intelligence’ in T Pihlajarinne, J Vesala and O Honkkila (eds), *Online Distribution of Content in the EU* (Edward Elgar 2019) 131; Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law’ (2018) 39 *Cardozo Law Review* 2260 et seq.; Andreas Engel, ‘Can a Patent Be Granted for an AI-Generated Invention?’ (2020) *GRUR International* 1123 et seq. (reviewing the possible negative aspects of granting patents to inventions made by AI, including the lack of an effective recipient of the incentives arising from the patent); Anne Lauber-Rönsberg and Sven Hetmank, ‘The Concept of Authorship and Inventorship Under Pressure: Does Artificial Intelligence Shift Paradigms?’ (2019) 14(7) *JIPLP* 570 et seq. (stating that whom the invention incentive for human inventors could be reduced by the provision of identical rules for protection).

¹³³² To gain a comprehensive understanding of the various positions on this issue, see: Jo Bac, *Artificial Intelligence: A Dependent Legal Person – An Evolutionary Step for the United States Patent Law* (Academia Press 2018) 35 et seq. In general, the preferable solution seems to be the one put forward by Fritz Machlup, *An Economic Review of the Patent System* (Committee Print, Washington 1958) 79 et seq.

¹³³³ Mark A Lemley and Dan L Burk, ‘Policy Levers in Patent Law’ (2003) 89 *Virginia Law Review* 1639 et seq.

¹³³⁴ Daniele Cerulla, ‘La Brevettabilità delle Invenzioni Realizzate dall’Intelligenza Artificiale’ (PhD thesis, University of Pavia 2022) 166 et seq.

¹³³⁵ Peter G Picht, Valerie Brunner and Rena Schmid, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (MPI Research Paper No. 22-08, 28 May 2022) 32.

¹³³⁶ Ryan Abbott, ‘I Think, Therefore I Invent: Creative Computers and the Future of Patent Law’ (2016) 57(4) *Boston College Law Review* 1125 et seq.

The patent system comes back to the need for sufficient incentives for companies to invest in AI-driven research and development, as AI is a crucial driver of technological progress now and in the future.¹³³⁷ The growing significance of AI's role in the invention process is undeniable, and addressing its implications will become increasingly important in the years to come.¹³³⁸ The pressure for changes in the system due to AI-related inventions presents an opportunity to reevaluate the current patent system's structure, which largely evolved due to historical accidents.¹³³⁹

The following subsections introduce enhancement propositions to make the patent framework more responsive to AI-related inventions.

2. Problems and Proposed Changes

a) Lead Time and First Mover Advantage Instead of Patent Protection

One of the primary advantages of patents is the exclusivity they confer; however, in certain technological fields, particularly those characterised by rapid innovation such as AI, the true strategic benefit may lie in lead time and first-mover advantage. Companies could prefer not to patent inventions and take advantage of lead time and being the first mover.¹³⁴⁰ Lead time refers to the period between the inception of an invention and its market introduction, and it allows firms to establish a competitive presence before rivals can react. In this context, first-mover advantage may be more valuable than legal exclusivity, especially where products have short life cycles or where enforcement of patent rights is uncertain or delayed.

For example, firms such as Apple have historically secured their dominant market positions not by being the first to invent, but by rapidly bringing refined products to market and later using patents more defensively. In the AI domain, lead time becomes particularly crucial given the limitations of the current patent framework in accommodating the specificities of AI-related inventions, not only because of unresolved questions around inventorship in fully autonomous outputs, but also due to disclosure challenges and the unpredictability of examination outcomes.

Companies may strategically prioritise secrecy and speed over disclosure and formal protection, particularly where valuable datasets and trained models can be effectively safeguarded as trade secrets.¹³⁴¹ In this setting, the accelerated development cycles characteristic of AI reduce the

¹³³⁷ Ronny Hauck and Baltasar Cevc, 'Patentschutz für Systeme Künstlicher Intelligenz' (2019) *Zeitschrift für Geistiges Eigentum* 135 et seq.; Oliver Baldus, 'Der Schutz von Erfindungen auf dem Gebiet der künstlichen Intelligenz' (2020) *Mitteilungen der deutschen Patentanwälte* 51 et seq.

¹³³⁸ Gaëtan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1473-74.

¹³³⁹ Nicholas A Pairolero et al., 'Closing the Gender Gap in Patenting: Evidence from a Randomized Control Trial at the USPTO' (2022) 17(3) *American Economic Journal: Economic Policy* 218 et seq. (for an example of the use of an RCT to measure the effect of a change in patent examination procedure).

¹³⁴⁰ For more on the benefits for first movers see: Uly Y Nafizah, Stephen Roper and Kevin Mole, 'Estimating the innovation benefits of first-mover and second-mover strategies when micro-businesses adopt artificial intelligence and machine learning' (2023) 62 *Small Business Economics* 411 et seq.

¹³⁴¹ Ana P Gonzalez Torres, 'AI-generated inventions: (A)I, inventor?' (Ius In Itinere, 27 April 2022) <https://www.iusinitinere.it/ai-generated-inventions-ai-inventor-42263>; for more on the advantages of secrets vs. patents see also: Klaus Kultti et al., 'Secrecy versus Patenting' (2007) 38(1) *The RAND Journal of Economics* 22

window during which exclusivity, whether formal or *de facto*, is commercially relevant. Thus, firms may rely on lead time to secure market dominance, accepting that the transient nature of such advantages limits the practical utility of patents unless they can be obtained and enforced within a similarly short time frame.

The first mover advantage grants the first entity to introduce and market its products or services a significant competitive edge, including a head start over competitors and the opportunity to secure a large portion of the market.¹³⁴² This advantage emerges endogenously and is particularly pronounced in AI systems, where introducing new and advanced technology can yield substantial profit margins and various other benefits.

First, the first mover often attains technological leadership. By pioneering innovative technology, first movers can achieve significant cost advantages, enabling them to sustain market share leadership.¹³⁴³ Although technological pioneers can protect their research and development through patents, in many industries, patents provide only weak protection, are easily circumvented, and are transient in value due to the rapid pace of technological change. This is especially relevant in AI, where existing patent laws may not apply effectively, underscoring the importance of first-mover advantage.

Second, first movers can secure a near-monopoly status in the market, allowing them to control marginal revenue and cost by selling at premium rates and limiting production to below-demand levels. This monopoly-like position typically results in higher profits than would be achievable in an open market with more competitors.¹³⁴⁴

Third, first movers can control critical resources by selecting the most attractive market niches and limiting opportunities for subsequent entrants. This control extends to geographic or product spaces, where early entrants can establish positions that make it unprofitable for later competitors to enter, potentially deterring them through price warfare and leveraging sunk investment costs.¹³⁴⁵

Fourth, first movers often build strong consumer loyalty. Customers may stick with the first brand that satisfactorily meets their needs, leading to a significant burden for competitors trying to lure them away, particularly if the pioneer has already shaped product standards and created switching costs.¹³⁴⁶

et seq.; in this context see also: Erik Weibust, and Dean A Pelletier, ‘Protecting AI-Generated Inventions as Trade Secrets Requires Protecting the Generative AI as Well’ (IPWatchdog, 24 July 2022) <https://ipwatchdog.com/2022/07/24/protecting-ai-generated-inventions-trade-secrets-requires-protecting-generative-ai-well/id=150372/>.

¹³⁴² Marvin B Lieberman and David B Montgomery, ‘First-Mover Advantages’ (1988) 9 *Strategic Management Journal* 41 (surveying the theoretical and empirical mechanisms that confer advantages as well as disadvantages on first-mover firms); Geoffrey A Pigman et al., ‘First Mover Advantages in International Business and Firm-Specific Political Resources’ (2006) 27(4) *Strategic Management Journal* 321 et seq. (stating that first-mover advantages arise endogenously; in the case of AI systems, exposing new and advanced technology generates substantial profit margins, along with several other advantages).

¹³⁴³ Shlomit Yansky Ravid and Ziaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: An Alternative Model for Patent Law at the 3A Era’ (2018) 39 *Cardozo Law Review* 2261 et seq.

¹³⁴⁴ Ibid.

¹³⁴⁵ Ibid.

¹³⁴⁶ Ibid.

Fifth, first movers in the AI industry have a significant advantage in their ability to create formidable market barriers that effectively block future competitors. One such barrier is the strategic use of pricing tactics, such as reducing prices to unsustainable levels for new entrants, a practice known as price dumping.¹³⁴⁷ The most potent market barrier in the context of AI inventions stems from the unique data generated by the AI products themselves. When an AI invention is deployed and utilized by customers or users, it generates a wealth of data that becomes available to the product's manufacturer or inventor. This data, which is often proprietary and specific to the first mover's AI system, can be leveraged as a powerful competitive advantage. First movers can use this exclusive data to further train and refine their AI models, leading to subsequent AI inventions that are superior to the original. Competitors, lacking access to the same data, are unable to replicate the first mover's AI capabilities, creating a significant barrier to entry. This data-driven advantage is particularly effective in the AI industry, where data availability is a critical factor in driving innovation and adoption.

The implications for companies engaged in developing AI-related inventions are profound. They may need to adopt strategies that prioritise lead time and the exploitation of first mover advantages over conventional patent protections. Lead time can be interesting within the AI industry, since the research and development of the initial AI system can be long, leading to an extended lead time compared to competitors that start later. At the same time, the resulting invention could potentially have a short product life cycle, given that AI system can generate inventions faster than traditional means. While both advantages may diminish over time, they often translate into more enduring competitive advantages.¹³⁴⁸ First movers can stay ahead of rivals by continuously improving their inventions, and switching costs may discourage customers from adopting competitor products. Although the average duration of monopoly status for first movers has decreased, research indicates that the first-mover advantage remains significant, with an increase in sales volume over time due to this effective monopoly. For AI-related inventions, industry players are likely to prioritize first-mover strategies over reliance on the traditional, and often outdated, patent regime, capitalizing on the numerous advantages of being the first to market.¹³⁴⁹

While the arguments for prioritising lead time and first mover advantages in the context of AI-related inventions are compelling, the introduction of an "expedited patent track model" could solve the problem and still keep protection through patents attractive.

¹³⁴⁷ Dan L Burk and Mark A Lemley, *The Patent Crisis and How the Courts Can Solve It* (The University of Chicago Press, 2009) 192; Adam B Jaffe and Josh Lerner, *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It* (2004) 57; Ted Sichelman and Stuart J H Graham, 'Patenting by Entrepreneurs: An Empirical Study' (2010) 17 *Mich Telecomm & Tech L Rev* 111, 137; Eric Goldman, 'Fixing Software Patents' 'Fixing Software Patents' (Santa Clara University School of Law, January 2013) <http://digitalcommons.law.scu.edu/facpubs/596>.

¹³⁴⁸ Shlomit Yansky Ravid and Ziaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: An Alternative Model for Patent Law at the 3A Era' (2018) 39 *Cardozo Law Review* 2261 et seq.

¹³⁴⁹ *Ibid.*

b) Introducing an “Expedited Patent Examination”

One procedural issue affecting the protection of AI-related inventions concerns the timing of patent examinations, which may contribute to a *post hoc* bias. While the EPO generally aims to issue a search report within six months and a first examination report within approximately twelve months, actual timelines can vary considerably depending on technical complexity and workload.¹³⁵⁰ Although accelerated examination options are available under programs such as PACE, these are not universally applicable or used.¹³⁵¹ In light of this, clearer procedural guidance and an accelerated framework may be warranted to reduce the strategic incentive to conceal material aspects of the invention’s development process.

In the context of AI-related inventions, the protracted examination process, combined with legal uncertainties surrounding the role of AI in the inventive step, may unintentionally incentivise applicants to downplay or omit the AI component in the disclosure. Given the ongoing difficulties in delineating when an invention is *merely* AI-assisted versus *substantially* AI-generated, applicants may seek to avoid potential objections by obscuring the AI’s contribution. These risks undermining the clarity and transparency of the disclosure, which in turn compromises legal certainty and the public function of the patent system.

One of the setbacks of a long examination period is that an invention that was nonobvious at the time of its conception might appear obvious when later evaluated by the patent office or courts, potentially years after its creation, making it difficult to think back to the state of technology of the filing date.¹³⁵² This lengthy patent examination process contrasts with the rapid growth of the AI industry.¹³⁵³ The swift evolution of AI technology increases the likelihood of hindsight rejections during extended examination periods. Still, this can be mitigated by considering the state of technology at the time of the patent application rather than at the time of examination with the tools and adjustments proposed in the “Skilled Person 2.0” model. Another setback is that AI-related inventions, as often the case with technological innovation, become obsolete after a few months and a patent is no longer relevant.

Thus, to address the issue of prolonged examination periods in the context of AI, it is proposed to implement accelerated patent examinations and a corresponding shorter patent lifespan for AI inventions, taking into account the rapid obsolescence of such technology.

¹³⁵⁰ EPO, ‘Examination’ <https://www.epo.org/en/about-us/services-and-activities/quality/statistics/examination>; Eva Ehlich and Naho Fujimoto, ‘EPO Timelines - The EPO Speeds Up Patent Examination and Opposition’ (Maiwald, April 2019) https://www.maiwald.eu/fileadmin/Download/PDF/2019-04_NF_EPO_Timelines.pdf; Julie Richardson, ‘Quality and Service at the EPO’ (Reddie & Grose, 11 July 2017) <https://www.reddie.co.uk/2017/07/11/quality-service-epo/>.

¹³⁵¹ Julie Richardson, ‘Quality and Service at the EPO’ (Reddie & Grose, 11 July 2017) <https://www.reddie.co.uk/2017/07/11/quality-service-epo/>.

¹³⁵² Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) SSRN 11.

¹³⁵³ The average wait time for the USPTO to deliver the results of the first substantive examination of a patent application is approximately 21 months and the total patent pendency is in average 32 months (Erickson Law Group, ‘How long does it take to get a patent?’ <https://www.ericksonlawgroup.com/law/patents/patentfaq/how-long-does-it-take-to-get-a-patent/>; USPTO, ‘Patents Examination’ <https://www.uspto.gov/patents/laws/america-invents-act-aia/patents-examination>).

Singapore, for example, has introduced the “Accelerated Initiative for Artificial Intelligence (AI²)”, a fast-track program specifically for AI-related patent applications that are first filed in Singapore, with the promise of granting a patent within six months.¹³⁵⁴

This aligns with the proposition of a new “AI patent track model” proposed by *Yanisky-Ravid* and *Jin*, which offers a comprehensive framework to address the challenges posed by AI-related inventions.¹³⁵⁵ This model is grounded in four key pillars: Firstly, it recognises the difficulty in categorizing AI-related outputs within traditional patentable subject matter.¹³⁵⁶ The model suggests extending patent protection to encompass creative AI systems, including both algorithms and trained models, as well as AI-related inventions. This approach aims to incentivise investment and innovation in AI technologies. Secondly, to address the “Black Box” Conundrum, the model proposes a depository system similar to that used for microorganism patents, where AI working models would be submitted to the patent office. This would ensure sufficient disclosure and enable reproducibility of the invention. Thirdly, given AI’s capabilities, the model recommends redefining this standard to a “skilled person using an ordinary AI tool in the art”, acknowledging the integration of AI tools in the inventive process. Lastly, the model advocates for a distinct patent track dedicated to AI inventions, featuring expedited examination processes assisted by AI tools and a shortened patent term to reflect the rapid pace of technological advancement in AI. This specialized track aims to provide clarity and efficiency in the patenting process for AI-related innovations.

Of the alternatives proposed by different scholars, this approach seems the most fitting, therefore the proposition of a two-track system can be taken into consideration for the EPO, but as explained in the next subchapter, without the differentiation between AI-related and not AI-related inventions.

c) Implementing a “Two-Track” Patent System

It is often emphasized that AI-related inventions significantly shorten the overall cycle of innovation and accelerate technological advancement at an increasingly rapid pace.¹³⁵⁷ From the perspective of patent law and incentive theory, there is a discernible connection between the length of innovation cycles and the incentive effect of a patent, both in terms of the static-positive incentive and the dynamic-negative incentive provided by patent law.¹³⁵⁸ In many AI-driven sectors, the invention process is notably fast, and the resulting outputs may have

¹³⁵⁴ Chong Koh Ping, ‘Singapore to fast-track AI patent applications’ (The Straits Times, 27 April 2019) <https://www.straitstimes.com/tech/singapore-to-fast-track-ai-patent-applications>; ‘Accelerated Initiative for Artificial Intelligence’ (ASEAN Intellectual Property Portal, 25 April 2019) <https://www.aseanip.org/latest-news-events/2023/03/03/accelerated-initiative-for-artificial-intelligence>.

¹³⁵⁵ Shlomit Yanisky-Ravid and Regina Jin, ‘Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic’ (2020) *SSRN* 5.

¹³⁵⁶ *Ibid.*

¹³⁵⁷ Oskar Paulini, ‘Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz’ (PhD thesis, LMU Munich 2023) 234.

¹³⁵⁸ *Ibid.*

comparatively brief commercial relevance due to rapid technological obsolescence.¹³⁵⁹ In this sense, an AI-system that produces an invention is likely to produce an improved version of the invention after a few months/years. However, this is not uniformly true across all AI use cases. For instance, in the case of AI-related pharmaceuticals, development timelines and regulatory approval processes may result in longer life cycles. Accordingly, a one-size-fits-all approach to patent duration may be inappropriate. Nonetheless, it is often advocated that the patent term for certain AI-related inventions could be shortened in order to facilitate earlier entry into the public domain, thereby accelerating knowledge dissemination in rapidly evolving technological fields.¹³⁶⁰

While some may argue that shortening the patent lifespan could discourage AI research and development, it is maintained that a reduced patent term would still cover the most valuable period for exclusive rights to make, sell, use, and import the invention.¹³⁶¹ The effectiveness of patents in incentivizing innovation, particularly in industries with rapidly shortening innovation cycles, hinges on whether subsequent inventions are independent or complementary.¹³⁶² Independent inventions do not rely on existing patents, allowing inventors to benefit from their exclusivity during the patent's amortization period. In contrast, complementary inventions depend on already patented technologies, extending the amortization period and complicating the innovation landscape. This reliance can deter new inventors due to potential infringement risks and high licensing costs, potentially stifling further advancements.¹³⁶³ Thus, understanding the nature of these relationships is crucial for fostering a dynamic innovation environment and ensuring that patent systems effectively support continuous technological development.

The consequences of the nature of inventions, whether independent or complementary, are particularly significant for AI-related inventions. In the fast-paced AI industry, where innovation cycles are short, the reliance on existing patented technologies can impact the incentive structures provided by patents. For example, although pharmaceutical companies may seek to protect their drugs under patent for as long as possible, a drug developed to treat the SARS-CoV-2 may not need a full 20-year term of exclusive rights, given the likelihood of virus evolution, potential upgrades to the drug formula, and the introduction of competitor drugs. However, removing patent rights from a pharmaceutical company would likely eliminate the incentives needed to recover the substantial costs associated with years of drug research and development. Without the benefits conferred by patents, scientists and researchers may feel inadequately compensated for their efforts.¹³⁶⁴ In AI, similar dynamics apply; if new

¹³⁵⁹ Shlomit Yansky Ravid and Ziaoqiong (Jackie) Liu, 'When Artificial Intelligence Systems Produce Inventions: An Alternative Model for Patent Law at the 3A Era' (2018) 39 *Cardozo Law Review* 2254.

¹³⁶⁰ Article 63(1) EPC; see also: EPO, 'Where is a patent valid and how long does it last?' <https://www.epo.org/en/service-support/faq/patents-and-ip/where-patent-valid-and-how-long-does-it-last>.

¹³⁶¹ Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 18.

¹³⁶² Oskar Paulini, 'Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz' (PhD thesis, LMU Munich 2023) 235.

¹³⁶³ Ibid.

¹³⁶⁴ Adam Mossoff, 'Patent Term Extensions Will Help Speed up Development of Coronavirus Drugs' (Hudson Institute, 12 March 2020) <https://www.hudson.org/research/15811-patent-term-extensions-will-help-speed-up-development-of-coronavirus-drugs>; Shlomit Yanisky-Ravid and Regina Jin, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN* 20-21.

technologies depend on existing patents, the extended amortization period may deter innovation due to fears of infringement or high licensing fees. Consequently, without adequate patent protections, companies might feel inadequately compensated for their efforts, leading to a potential slowdown in innovation as they prioritize lead time and first-mover advantages instead. Balancing patent rights with the need for rapid innovation is essential to ensure that companies remain motivated to develop groundbreaking AI technologies while also addressing public access concerns and competitive dynamics in the market.

A potential solution to accommodate the rapid pace of innovation in certain industries could involve implementing a two-track patent system, offering applicants the flexibility to choose between two different examination procedures:

- (a) The first option would be a “standard examination procedure”, following the traditional process of granting a patent with a 20-year protection period.
- (b) The second option could be an “expedited examination procedure”, wherein the patent application is reviewed and decided within a shortened timeframe, such as six months from the filing date. This timeframe should be feasible also for complex AI-related inventions, with often involve technical considerations that necessitate thorough examination to assess novelty and inventive step. This expedited process would confer patent protection for a limited duration, for example, five years, and might require higher fees to offset the increased workload at the EPO. An option to extend or convert to standard patents under certain conditions could also be considered.

In this framework, certain sectors, such as pharmaceutical companies deploying AI in the development of urgent medical solutions like vaccines for emerging viruses, could benefit from an expedited patent procedure to facilitate earlier market access, even if the duration of protection is limited. Likewise, companies operating in rapidly evolving technological domains, such as software or consumer electronics, may favour a shorter term of protection aligned with the brief commercial relevance of their products. Instead of relying solely on trade secrets to preserve a competitive advantage during lead times, short-term patent protection could offer a formalised and enforceable exclusivity, while ensuring that the disclosed knowledge enters the public domain in a timely manner, thereby advancing broader societal interests.

Still, by not making the “expedited examination procedure” obligatory, companies can still opt for the classic patent route and protection. If AI inventions receive automatically a different treatment, applicants may attempt to characterize their inventions as “non-AI” to avoid the shorter protection. Historical examples, such as the USPTO’s “second pair of eyes” review for business method patents, show that applicants can adapt their applications to circumvent additional scrutiny.¹³⁶⁵ This way, it is up to who files the patent to decide which track they prefer.

¹³⁶⁵ John R Allison and Starling D Hunter, ‘On the Feasibility of Improving Patent Quality One Technology at a Time: The Case of Business Methods’ (2006) 21 *Berkeley Technology Law Journal* 729.

d) Inspirations from the German Utility Model

Against this backdrop, one might question why an unexamined utility model would not be sufficient as a more expedient form of protection. The German utility model system (*Gebrauchsmuster* - “GebrMG”) affords legal protection for technical inventions without requiring substantive examination on inventive step. As such, they allow for significantly expedited registration, often within a matter of weeks, at comparatively low cost. The protection term is limited to a maximum of ten years.¹³⁶⁶

The substantive scope of such a model would be comparable to that of a patent in terms of exclusive usage and exclusion rights),¹³⁶⁷ though with a shorter protection term and a simplified grant procedure.¹³⁶⁸ The latter would omit examination of novelty, inventive step, and industrial applicability,¹³⁶⁹ which could help alleviate administrative burden on patent offices in light of the expected proliferation of AI-related inventions.¹³⁷⁰ The risk of mass filings could be mitigated by maintaining the possibility of post-registration invalidation requests.¹³⁷¹

Utility models should in general be applicable to AI-related inventions. German utility model law excludes methods and processes from protection,¹³⁷² which narrows the scope for AI-systems (Categories I-III), but not for AI-related inventions that do not involve algorithmic procedures, training methods, or software-implemented processes.¹³⁷³

Still, due to the absence of prior substantive examination, utility models are inherently more vulnerable to invalidity challenges. Their legal enforceability often hinges on the outcome of post-registration litigation, which can undermine their deterrent effect. While utility models may offer rapid and provisional protection, they do not guarantee the legal certainty typically afforded by examined patent rights.

Accordingly, while utility models offer advantages in terms of speed and cost, their constrained scope and heightened vulnerability to invalidation render them less suitable for the nuanced demands of AI innovation.¹³⁷⁴ A two-track patent system, by contrast, could accommodate diverse innovation cycles across industries. Despite its higher costs and longer timelines, it would preserve the legal certainty and substantive scope necessary to foster and protect AI-driven technological advancement. Nonetheless, utility models could still play a complementary role within a broader protection strategy, especially in cases where rapid time-to-market is critical and if an “expedited examination procedure” should not be feasible at the

¹³⁶⁶ Deutsches Patent- und Markenamt, *Gebrauchsmuster*, <https://www.dpma.de/gebrauchsmuster/>.

¹³⁶⁷ § 11(1) GebrMG; § 9 sentence 1, 2 no. 1 PatG.

¹³⁶⁸ Tim W Dornis, ‘Künstliche Intelligenz und Innovation – Perspektiven der Disruption im Patentrecht (Teil 2)’ (2020) *Mitteilungen der deutschen Patentanwälte* 482 et seq.

¹³⁶⁹ § 8(1) sentence 2 GebrMG.

¹³⁷⁰ Tim W Dornis, ‘Künstliche Intelligenz und Innovation – Perspektiven der Disruption im Patentrecht (Teil 2)’ (2020) *Mitteilungen der deutschen Patentanwälte* 482 et seq.

¹³⁷¹ Daniel Köhl, ‘Autonome KI-Programme als Erfinder im Patentrecht’ (2025) *GRUR* 635.

¹³⁷² (§ 1(2) GebrMG.

¹³⁷³ Daniel Köhl, ‘Autonome KI-Programme als Erfinder im Patentrecht’ (2025) *GRUR* 635.

¹³⁷⁴ Anne Lauber-Rönsberg and Sven Hetmank, ‘The Concept of Authorship and Inventorship Under Pressure: Does Artificial Intelligence Shift Paradigms?’ (2019) 14(7) *JIPLP* 571 et seq.; Daniel Köhl, ‘Autonome KI-Programme als Erfinder im Patentrecht’ (2025) *GRUR* 635.

EPO.¹³⁷⁵ In such contexts, utility models may serve as a preliminary protection tool while a corresponding patent application undergoes full examination.

3. Potential Challenges

a) Surge in Patent Applications and Patent Office Challenges

The granting of patents for inventive AI outputs is likely to result in a substantial increase in the number of patent filings. The potential flood of patent applications and the rise of patent trolls are significant concerns in the context of AI-related inventions.¹³⁷⁶ Patent offices are currently ill-equipped to handle such a wave of applications, potentially leading to various problems including delays or the issuance of low-quality patents.¹³⁷⁷ This influx could advantage large corporations with resources to file and defend numerous patents, while smaller companies or research institutions prioritizing research and development may struggle to keep up.¹³⁷⁸

Given that AI-driven invention systems typically incur high fixed costs during development, but once operational, generating additional inventions has relatively low incremental costs, this can result in the generation of many potentially low-value inventions.¹³⁷⁹ This concept aligns with economic theory. As the marginal cost of producing inventions decreases, there is an incentive to generate more inventions, even if their individual value is lower.¹³⁸⁰

Even though not all AI-related inventions are patentable, the rise of “invention machines” could have significant implications for the patent system.¹³⁸¹ Owners of these machines might choose not to patent their inventions but instead generate a vast amount of prior art. This prior art would inevitably become part of the literature used to assess the inventive step of new inventions,

¹³⁷⁵ For a more detailed discussion on the relationship between time-to-market considerations and optimal patent award structures see: Benjamin N Roin, ‘The Case for Tailoring Patent Awards Based on Time-to-Market’ (2014) 61(3) *UCLA Law Review* 672 et seq.

¹³⁷⁶ For a more in dept discussion on patent trolls see: Ansgar Ohly, “‘Patenttrolle’ oder: Der patentrechtliche Unterlassungsanspruch unter Verhältnismäßigkeitsvorbehalt? – Aktuelle Entwicklungen im US-Patentrecht und ihre Bedeutung für das deutsche und europäische Patentsystem’ (2008) *GRUR International* 787 et seq.; see also: Michael J Meurer, ‘Business Method Patents and Patent Floods’ (2002) 8 *Washington University Journal of Law & Policy* 309 et seq.

¹³⁷⁷ Adrian Lobe, ‘Kreative Computer - Wenn die Software zum Erfinder wird’ (Neue Zürcher Zeitung, 14 June 2016) <https://www.nzz.ch/feuilleton/kuenstliche-intelligenz-kreative-computer-wenn-die-software-zum-erfinder-wird-ld.88633>.

¹³⁷⁸ Bronwyn H Hall and Rosemarie H Ziedonis, ‘The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry, 1979-1995’ (2001) 32 *RAND Journal of Economics* 101-128; Gideon Parchomovsky and R Polk Wagner, ‘Patent Portfolios’ (2005) 154(1) *University of Pennsylvania Law Review* 49 et seq.

¹³⁷⁹ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1470-71.

¹³⁸⁰ Alfonso Gambardella, Dietmar Harhoff and Bart Verspagen, ‘The Economic Value of Patent Portfolios’ (2017) 26(4) *Journal of Economics & Management Strategy* 735.

¹³⁸¹ One such initiative is already under way, see <http://allpriorart.com/>. A key question is whether the disclosures by the AI would be enabling.

potentially raising the bar for patentability in certain fields to the point where obtaining patents becomes exceedingly difficult.

Some companies might intentionally flood a technological domain with prior art to secure freedom to operate, creating patent-free zones with unpredictable effects on product development and commercialisation. This scenario parallels the concept of an “AI-augmented” person skilled in the art. The concern is not that this AI-augmented individual could have created the invention, but rather that the existence of an extensive body of prior art would render the invention obvious.¹³⁸²

While these challenges present significant concerns, one might argue that they also foster an environment ripe for innovation. The existence of abundant prior art could encourage inventors to think creatively and develop truly novel solutions rather than relying on existing patents. By reducing barriers to entry in certain domains, this could stimulate competition and lead to accelerated technological advancements.

b) Patent Concentration and Innovation Stifling

One major concern is the concentration of AI-related patents among a few large entities. Autonomous invention-generation systems can produce numerous inventions, potentially concentrating patent ownership and stifling innovation.¹³⁸³ This scenario could lead to a situation where access to patented technologies becomes prohibitively expensive, especially when multiple patent holders are involved.¹³⁸⁴

Entities owning AI-driven invention systems could accumulate extensive patent portfolios, gaining strategic advantages over competitors. Research by *Choi* and *Gerlach* suggests that an expansion in one firm’s patent portfolio can significantly diminish a rival’s incentives to innovate and introduce new products.¹³⁸⁵

This situation could lead to chilling effects on innovation and exacerbate the problem of patent thickets, where overlapping and fragmented patent rights increase litigation risks and make the costs of clearing these rights prohibitively high.¹³⁸⁶ This issue is especially pronounced in industries where multiple patented technologies are essential for producing a single product, such as in the smartphone industry.

¹³⁸² Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, ‘AI-Generated Inventions: Implications for the Patent System’ (2024) 96(6) *Southern California Law Review* 1471 et seq.

¹³⁸³ Ben Hattenbach and Joshua Glucoft, ‘Patents in an Era of Infinite Monkeys and Artificial Intelligence’ (2015) 19 *Stanford Technology Law Review* 32 et seq.

¹³⁸⁴ Michael A Heller and Rebecca S Eisenberg, ‘Can Patents Deter Innovation? The Anticommons in Biomedical Research’ (1998) 280 *Science* 698-701.

¹³⁸⁵ Jay P Choi and Heiko Gerlach, ‘A Theory of Patent Portfolios’ (2017) 9(1) *American Economic Journal: Microeconomics* 344.

¹³⁸⁶ Carl Shapiro, ‘Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting’ in Adam B Jaffe, Josh Lerner and Scott Stern (eds), *Innovation Policy and the Economy I* (MIT Press 2001) 119; Rosemarie H Ziedonis, ‘Don’t Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms’ (2004) 50 *Management Science* 804 et seq.

c) The Risk of Patent Trolling and Declining Innovation Quality

The accessibility of AI technology for inventions could trigger a surge in patenting activity, leading to a decline in the quality of innovation and the proliferation of “patent trolling”. Patent trolling involves patenting inventions not for their implementation but to build a portfolio aimed at finding infringers for financial gain.¹³⁸⁷ If AI systems can generate numerous inventions with minimal effort, the fundamental principles underlying patent law may need to be re-evaluated and realigned.¹³⁸⁸

Critics of patenting AI-related inventions argue that doing so could exacerbate the issue of patent thickets, hindering innovation rather than promoting it.¹³⁸⁹ Patent thickets are already problematic in the current system and the inclusion of AI-related inventions could intensify the problem by increasing the number of patents, raising examination and licensing costs, and complicating the commercialization of new products.¹³⁹⁰ The implications of vast patent

¹³⁸⁷ As part of the “All Prior Art” project, for example, the roboticist and computer scientist Alex Reben has developed an algorithm that generates millions of inventions with the sole aim of preventing them from being patented. The point here is that if they are made available to the public, they are no longer considered new - and thus no longer patentable. The system extracts offset pieces from patents that have already been applied for and merges them into new types of instructions. The patents listen to bulky abbreviations such as “1461187712-3f68906c-5b50-4e26-a28c-e9e5ef4d0643” and are basically nonsense manuals that combine technical devices or techniques that are incompatible with each other - for example a robotic phone book and a nasal plug decorated with magnetic jewellery. The project is aimed at “patent trolls” who more or less randomly apply for patents with the prospect of lucrative profits. Now speculation is part of the nature of business, and it has never been possible to properly deal with patent gamblers. However, the costs of these computer-generated ideas tend towards zero. (Overview available at <https://allpriorart.com/about/>; Lawrence B Ebert, ‘More on All Prior Art Database of Alexander Reben; the USPTO Responds (Sort of)’ (IPbiz.blogspot, 12 April 2016) <http://ipbiz.blogspot.com/2016/04/more-on-on-all-prior-art-database-of.html>; Bruce Berman, “All Prior Art” Algorithm Won’t Stop Bad Patents or Actors’ (IPcloseup, 6 June 2016) <https://ipcloseup.com/2016/06/06/all-prior-art-algorithm-wont-stop-bad-patents-or-actors/>; Aviva Rutkin, ‘Computer Generates All Possible Ideas to Beat Patent Trolls’ (New Scientist, 18 April 2016) <https://www.newscientist.com/article/2084755-computer-generates-all-possible-ideas-to-beat-patent-trolls/>); see also: Christoph Ann, ‘Patent Trolls – Menace or Myth?’ in W P Waldeck and Pymont (eds), *Patents and Technological Progress in a Globalized World: Liber Amicorum Joseph Straus* (Berlin and Heidelberg 2009) 356 et seq.

¹³⁸⁸ Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 1 et seq. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3168703; Shlomit Yanisky-Ravid and Xiaoqiong (Jackie) Liu, ‘When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law’ (2018) 39 *Cardozo Law Review* 2232 et seq.

¹³⁸⁹ The term ‘patent thickets’ seems to derive from the litigation between SCM and Xerox in the 1970s and 1980s (*In re Xerox Corp* 86 FTC 364 (1975); *SCM Corp v Xerox Corp* 645 F.2d 1195 (2d Cir 1981)). See also: Carl Shapiro, ‘Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting’ in Adam B Jaffe, Josh Lerner and Scott Stern (eds), *Innovation Policy and the Economy I* (MIT Press 2001) 119.

¹³⁹⁰ Liza Vertinsky and Todd M Rice, ‘Thinking about thinking machines: Implications of Machine Inventors for Patent Law’ (2002) 8(2) *Boston University Journal of Science and Technology Law* 608; Peter Blok, ‘The Inventor’s New Tool: Artificial Intelligence – How Does It Fit in the European Patent System?’ (2017) 39 *European Intellectual Property Review* 73; Thomas H Meitinger, ‘Künstliche Intelligenz als Erfinder?’ (2020) *Mitteilungen der deutschen Patentanwälte* 50; Mark A Lemley, ‘Patenting Nanotechnology’ (2005) 58 *Stanford Law Review* 618; Gavin Clarkson and David DeKorte, ‘The Problem of Patent Thickets in Convergent Technologies’ (2006) 1093(1) *Annals of the New York Academy of Sciences* 180; Olga Gurgula, ‘Strategic Accumulation of Patents in the Pharmaceutical Industry and Patent Thickets in Complex Technologies – Two Different Concepts Sharing Similar Features’ (2017) *IIC* 385.

portfolios and patent thickets suggest that rewarding AI-related inventions with as many patents as they produce might result in excessively substantial rewards.¹³⁹¹

d) Policy Responses to AI-Related Patent Proliferation

While it seems desirable to limit the strength of AI-related patent portfolios, the optimal mechanism to achieve this goal remains uncertain and warrants thorough theoretical investigation. From a patent-system-internal perspective, there should be no apprehension about granting patents to AI-related inventions as long as they meet the substantive patentability requirements.

To address the mentioned concerns, AI systems deployed by patent offices, such as the EPO, could assist in managing the increased number of patent applications resulting from AI-driven innovations.¹³⁹² Post-grant measures could also help alleviate the issue of patent thickets, such as reducing the scope of protection and the patent term for patents within certain fields.¹³⁹³

Another option to address these concerns include escalating application fees based on the size of the assignee's patent portfolio or for each new invention produced by the same AI system. Introducing conditions on patents stemming from invention systems that potentially diminish the patents' value could involve further differentiation within the patent system.¹³⁹⁴ However, this could be implemented in a manner that aligns with incentives rather than being wasteful. The decision of whether to seek approval for an invention machine and, if approved, whether to submit each new invention as a product of the machine or through the standard application process would be left to the applicants. The machine route might yield faster but less valuable patents, while the standard route would result in slower but more valuable patents.¹³⁹⁵ In principle, these trade-offs could be calibrated to limit the market power of extensive patent portfolios while still providing appropriate incentives to patent the most valuable inventions. Nonetheless, implementing a differentiated system would raise concerns in the political economy. While it seems desirable to limit the strength of AI-related patent portfolios, the

¹³⁹¹ Ashley Chuang, 'Fixing the Failures of Software Patent Protection: Deterring Patent Trolling by Applying Industry-Specific Patentability Standards' (2006) 16 *Southern California Interdisciplinary Law Journal* 232; Spencer Hosie, 'Patent Trolls and the New Tort Reform: A Practitioner's Perspective' (2008) 4(1) *I/S: A Journal of Law and Policy for the Information Society* 78; Sannu K Shrestha, 'Trolls or Market-Makers? An Empirical Analysis of Nonpracticing Entities' (2010) 110 *Columbia Law Review* 119; Robert P Merges, 'The Trouble with Trolls: Innovation, Rent-Seeking, and Patent Law Reform' (2009) 24(4) *Berkeley Technology Law Journal* 1603-04.

¹³⁹² Christian Heinze and Andreas Engel, 'KI und Patentrecht' in M Ebers et al. (eds), *Künstliche Intelligenz und Robotik* (Munich 2020) § 10 para 92; EPO, *Strategic Plan 2023* 44-46, 121; WIPO, Standing Committee on the Law of Patents, 'Background Document on Patents and Emerging Technologies' (28 May 2019) SCP/30/5, para 84 et seq.

¹³⁹³ Liza Vertinsky and Todd M Rice, 'Thinking about thinking machines: Implications of Machine Inventors for Patent Law' (2002) 8(2) *Boston University Journal of Science and Technology Law* 574, 596 et seq., 608; Erica Fraser, 'Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law' (2016) 13(3) *SCRIPTed* 332.

¹³⁹⁴ Gaétan de Rassenfosse, Adam B Jaffe and Melissa Wasserman, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1471.

¹³⁹⁵ *Ibid.*

optimal mechanism to achieve this goal remains uncertain and warrants thorough theoretical investigation.¹³⁹⁶

4. Updating Guidelines and Cooperation Amongst Patent Offices

a) Between “Institutional Realism” and “Societal Futurism”

Institutions, as the EPO in the case at hand, often take a cautious approach, adhering to a “business as usual” mindset when confronted with new technologies. *Schneider*, for example, analyses the EPO’s supranational autonomy and emphasizes that its technocratic focus on examining patentability criteria often comes at the expense of broader societal reflection on the implications of patents. She argues that, in its current structure, the EPO has little incentive to proactively engage with the societal implications of disruptive technologies.¹³⁹⁷ The approach of the EPO can be seen as “institutional realism”, which focuses on practicality and adherence to established norms, emphasizing the importance of existing structures, such as legal systems, bureaucratic organizations, and social hierarchies.¹³⁹⁸ It values stability and continuity in decision-making processes.

Kica and *Groenendijk* criticize the EPO for treating patents primarily as a legal-technical matter, thereby neglecting societal consequences.¹³⁹⁹ They advocate for greater inclusion of public interests and an adaptation of the patent system to evolving socio-political and scientific contexts.¹⁴⁰⁰ Furthermore, a report by *Lévy* and *Jouyet* highlights structural deficiencies in the EPO’s governance.¹⁴⁰¹ They point out the absence of political legitimacy within the EPO’s Administrative Council, leading to inadequate addressing of strategic issues concerning the patentability of new technologies. Instead, the Council focuses mainly on day-to-day management, which hampers necessary reforms.

In contrast, “societal futurism” can be seen as forward-thinking, exploring how technological advancements, cultural shifts, and emerging trends might drive societal changes.¹⁴⁰² This perspective encourages speculation about the future and considers how legal, political, and

¹³⁹⁶ Ibid.

¹³⁹⁷ Ingrid Schneider, ‘Governing the patent system in Europe: the EPO’s supranational autonomy and its need for a regulatory perspective’ (2009) 36(8) *Science and Public Policy* 619.

¹³⁹⁸ The term “institutional realism” does not have a single origin but has been used across disciplines, such as international relations, legal theory, and political philosophy, to describe approaches that combine a realist focus on power or practical functioning with attention to the structuring role of institutions (see for example: Robert Grafstein, *Institutional Realism: Social and Political Constraints on Rational Actors* (Yale University Press 1992)).

¹³⁹⁹ For a general discussion see: Evisa Kica and Nico Groenendijk, ‘The European patent system: dealing with emerging technologies’ (2011) 24(1-2) *Innovation: The European Journal of Social Science Research* 85 et seq.

¹⁴⁰⁰ Ibid.

¹⁴⁰¹ Maurice Lévy and Jean-Pierre Jouyet, ‘L’économie de l’immatériel: la croissance de demain’ (Report for the French Minister of Economy, Finance and Industry, 16 March 2006) <https://www.unitary-patent.eu/content/criticisms-governance-european-patent-office.html>.

¹⁴⁰² The term “societal futurism” lacks a formal origin but is occasionally used to describe future-oriented thinking concerned with large-scale social transformation, often situated within futures studies, speculative political theory, or techno-social forecasting.

social systems may need to evolve to meet these changes. It embraces innovation, anticipates challenges, and seeks to shape a future that meets the changing needs of society.

The tension between “institutional realism” and “societal futurism” encapsulates two divergent yet complementary modes of engagement with technological change. While the former is grounded in present institutional realities, the latter emphasises visionary adaptation. Striking an effective balance between these perspectives is essential if societies are to navigate current complexities while preparing for transformative future developments.

In this context, it is worth considering whether the EPO positions itself more firmly within the camp of “institutional realism” than other national or regional patent offices. One could argue that its supranational nature and the need to mediate between the legal and political expectations of multiple Member States necessitate a more conservative, continuity-focused posture. This institutional conservatism may, in turn, limit its capacity to anticipate and respond to the societal implications of disruptive innovation. This tension is particularly pronounced in relation to AI-related inventions, where the principle that “substance must prevail over form” becomes increasingly relevant, especially in the assessment of inventive step.¹⁴⁰³

b) Updating the Guidelines

Various countries are updating their patent examination guidelines to address AI-related inventions. For instance, China, Japan, Korea, the United Kingdom¹⁴⁰⁴ and the United States have all made recent updates to their guidelines, addressing issues such as subject matter eligibility, disclosure requirements, and the inventive step assessments for AI-related inventions.¹⁴⁰⁵ While amendments required to the EPC or its Implementing Regulations to address the issue of AI-related inventions may take time to implement, it is important to proactively address the issues in a timely matter by adapting the yearly changing EPO Guidelines to the new reality. Concrete steps can be taken, such as updating the person skilled in the art to a “Skilled Person 2.0”, enhance the use of AI in the prior art search and generally, use more AI tools to help patent examiners. For the time being, with these main changes, AI-related inventions would be eligible for patent protection.

Based on the analysis in this work, AI-related inventions appear to involve an inventive step. Patent law, with slight adjustment, seems to be fitting to protect AI-related inventions. There does not appear to be a compelling need for *a sui generis* right at present. Most challenges raised by AI-related inventions can be addressed through a careful reinterpretation and incremental adaptation of existing principles of the patent system.

¹⁴⁰³ Piergaetano Marchetti and Marco Ventoruzzo, ‘Chi fa le regole non può permettersi il lusso dell’ambiguità’ (Il Sole 24 Ore, 25 April 2023).

¹⁴⁰⁴ Oliver Bray, ‘UKIPO Releases New Guidance on Patentability of AI-Related Inventions’ (Lexology, 17 January 2023) <https://www.lexology.com/library/detail.aspx?g=01c82e3d-ef6c-49cc-bc76-b3da07b5214b>.

¹⁴⁰⁵ Stephen Hou, ‘International Patent Office Guidance on Artificial Intelligence Inventions’ (Solve Intelligence, 15 May 2024) <https://www.solveintelligence.com/blog-posts/international-patent-office-guidance-on-artificial-intelligence-inventions>.

In addition to the updates to the Guidelines proposed in this work, the role of secondary indicia in examining inventive step for AI-related inventions also warrants reconsideration by the EPO, with a more central role needed balanced with the overall problem-solution approach,¹⁴⁰⁶ especially in cases of uncertainty.¹⁴⁰⁷ Firstly, if the AI-related invention overcomes a known technical prejudice in its field, this can serve as an indication of non-obviousness.¹⁴⁰⁸ For example, if prior art pointed towards using a specific model, algorithm or dataset that the invention improves upon, overcoming this technical prejudice suggests an inventive step.¹⁴⁰⁹ Secondly, if the AI-related invention satisfies a long-standing but unsolved need in its technical field, where the prior art has been inactive for an extended period, this can demonstrate non-obviousness.¹⁴¹⁰ Thirdly, if the AI-related invention yields surprising or unexpected results compared to the prior art, this bonus effect can support an inventive step finding. For instance, if the invention's AI system generates a technical solution that is significantly more effective than what would be expected based on the prior art, this unexpected technical advantage can be a secondary indicium of non-obviousness.¹⁴¹¹ Fourthly, for commercial success, in the case of AI-related inventions, it may be important to demonstrate not only that the invention is commercially successful but also that the success is attributable to the AI-related features of the invention. This may require analysing market data and identifying specific aspects of the invention that contribute to its success.¹⁴¹² When it comes to AI from an economic point of view, the commercial success of the patented invention and the fact that it has been the subject of numerous licence applications, possibly for high fees, can constitute a valid indicium of inventive activity.¹⁴¹³

Building on the existing secondary indicia, *Ramalho* proposes adding “made by AI” as an additional factor to consider in the inventive step analysis.¹⁴¹⁴ According to her, the fact that an invention was generated by an AI system, rather than a human inventor, could serve as evidence of inventiveness. This new indicium recognizes the unique capabilities of AI in generating inventive technical solutions that may not be obvious to a person skilled in the art.¹⁴¹⁵ If an AI

¹⁴⁰⁶ These secondary indicators might include details about the process the inventor used to develop the invention, but such details do not necessarily prove the existence of an inventive step (Guy Tritton et al., *Intellectual Property in Europe* (Sweet & Maxwell 2002) 98 et seq.).

¹⁴⁰⁷ A comparable stance has been adopted by the EPO BoA, as noted in the Compendium of the EPO case law. It states that secondary indicia of non-obviousness become relevant primarily in situations of uncertainty, particularly when an objective assessment of prior art has not yet yielded a definitive conclusion (EPO, Case Law of the BoA 2022).

¹⁴⁰⁸ Maurice Schellekens, ‘Artificial Intelligence and the re-imagining of inventive step’ (2022) 13(2) *JIPITEC* 89 et seq.

¹⁴⁰⁹ EPO, T 60/89, 31 August 1990 (*Fusion Proteins*); EPO, T 631/89, 10 April 1992; EPO, T 695/90, 31 March 1992; EPO, T 1212/01, 3 February 2005 (*Pyrazolopyrimidinones for the treatment of impotence/PFIZER*).

¹⁴¹⁰ Guy Tritton et al., *Intellectual Property in Europe* (2nd edn, Sweet & Maxwell 2002) 97-98; see also: EPO, T 109/82, 15 May 1984 (*Hearing aid/Bosch*); EPO, T 255/91, 12 September 1991 (*Priority*); EPO, T 699/12, 13 November 2017.

¹⁴¹¹ EPO, T 0181/82, 28 February 1984 (*Spiro compounds*); see also: Andrea Ottolia, ‘Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30’, in L C Ubetazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (Wolters Kluwer 2019) sub art. 48 CPI.

¹⁴¹² Daniele Fabris, ‘From the PHOSITA to the MOSITA: Will “Secondary Considerations” Save Pharmaceutical Patents from Artificial Intelligence?’ (2020) *IIC* 698 et seq.

¹⁴¹³ Vincenzo Di Cataldo, *L'originalità dell'invenzione* (Giuffrè 1983) 73.

¹⁴¹⁴ Ana Ramalho, ‘Patentability of AI-generated inventions: is a reform of the patent system needed?’ (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 26.

¹⁴¹⁵ *Ibid.*

system is able to autonomously create an invention that satisfies a long-felt need or yields surprising results, the fact that it was “made by AI” could support a finding of inventive step. Still, as argued throughout this work, the author maintains that distinguishing the inventive process is unlikely to constitute a viable solution.

Revising the interpretative Guidelines, particularly at the level of the EPO, as proposed throughout this work but also with respect to secondary considerations for AI-related outputs could nonetheless enhance the accuracy of inventive step determinations in this emerging context.

c) Cooperation Amongst Patent Offices

Cooperation between patent offices may contribute positively to the overall functioning of the global patent system. Joint initiatives, such as the development of shared AI tools databases, have the potential to foster both collaboration and constructive competition. Such measures can improve procedural efficiency, promote a degree of standardisation, and support innovation across jurisdictions. The WIPO could assume a pivotal role in facilitating transparency and coordination among international IP offices.

An illustrative example of existing collaborative efforts is the interdisciplinary IP5 task force, which brings together the EPO, the Japan Patent Office, the Korean Intellectual Property Office, the China National Intellectual Property Administration, and the United States Patent and Trademark Office, in cooperation with WIPO. This task force engages with legal, technical, and policy questions raised by emerging technologies and AI, with a focus on their implications for patent systems and administrative practice.¹⁴¹⁶

Additionally, bilateral cooperation, such as that between the EPO and China since 2019, has yielded concrete outcomes. Their joint comparative study on software-related inventions has generated useful guidance for both applicants and legal practitioners.¹⁴¹⁷ WIPO has also initiated a public consultation process on AI and intellectual property, designed to gather stakeholder feedback on the challenges that AI presents for intellectual property policymakers. The results of this process may provide a basis for structured multilateral dialogue going forward.

However, while such cooperative efforts are undoubtedly valuable, they do not resolve the more fundamental and practical issues identified in this study. Many of the core challenges posed by AI-related inventions, such as doctrinal uncertainties surrounding inventorship and inventive step, or the institutional reluctance to adapt established examination practices, persist irrespective of international coordination. Hence, while collaboration should be encouraged, it cannot substitute for substantive legal and institutional reform.

¹⁴¹⁶ Stephen Hou, ‘International Patent Office Guidance on Artificial Intelligence Inventions’ (Solve Intelligence, 15 May 2024) <https://www.solveintelligence.com/blog-posts/international-patent-office-guidance-on-artificial-intelligence-inventions>.

¹⁴¹⁷ Yogita Sharma, ‘Patentability of AI Inventions’ (iPleaders, 29 January 2023) <https://blog.ipleaders.in/patentability-of-ai-inventions/>.

5. Preliminary Results

Rather than introducing a *sui generis* system, this work supports enhancing the existing patent framework to accommodate AI-related inventions. AI-related inventions are significantly accelerating the pace of technological advancement, leading to shorter innovation cycles that challenge traditional patent structures. The effectiveness of patents in incentivizing innovation is closely tied to whether subsequent inventions are independent or complementary. In the AI industry, where both invention and product life cycles can be brief, the standard 20-year patent term may be excessive, as the incentive for extended protection diminishes. To address these challenges, a proposed two-track patent system could offer applicants a choice between a standard 20-year term and an “expedited patent examination” with limited two-year protection. This approach would cater to fast-moving sectors like AI, allowing companies to secure short-term patents while ensuring public access to innovations sooner, thus balancing rapid innovation needs with broader societal benefits.

Patent offices, including the EPO, must update their examination guidelines to account for AI-related inventions. Cooperation among international patent offices, like the IP5 task force, could facilitate the development of shared databases and tools to better assess AI-generated inventions. Intellectual property offices must remain agile in addressing the challenges posed by AI, adapting the system as technology evolves.

To address concerns about the inventive step, patent examiners could adopt new methodologies, such as leveraging AI in prior art searches, for the person skilled in the art and to better assess whether AI-related inventions meet the necessary criteria. Additionally, AI could help increase the stringency of the inventive step requirement, preventing trivial innovations from receiving patent protection.

A *sui generis* system for AI-related inventions, while tempting, is ultimately unnecessary at this stage. Modifying and enhancing the existing patent framework offers a more pragmatic solution. Updating examination processes, shortening patent lifespans for certain inventions, and fostering international cooperation between patent offices will help ensure that the patent system remains relevant and effective in addressing the challenges posed by AI innovations. By maintaining a sole, adaptable patent system, patent law can continue to incentivize innovation while also safeguarding the public good.

H. CONCLUSION

The development of AI has seen a series of significant milestones over the past 80 years, from the creation of the first artificial neuron to the development of modern machine learning technologies and most recently general purpose AI models. The field continues to face both technical and legal challenges, particularly as AI systems become more advanced and able to assist human inventors or partly replace them in generating inventive output.

A review of the literature shows how the rise of AI will have a significant impact on the patent system. As AI continues to play a larger role in the invention process, it raises, amongst others, the following questions. Firstly, the applicability of traditional patent law doctrines to AI-related inventions, which encompass a broad range of technologies and innovations that leverage AI to perform tasks traditionally requiring human intelligence, as well as alternatives to patent protection are subject of debate and adaptations of the patent system as a whole are proposed. Secondly, the applicability of current patentability requirements, in particular the inventive step is questioned. Thirdly this work calls for a better integration of AI into patent examination processes. AI itself can enhance patent examination, improving efficiency by automating prior art searches and assessing the inventive step.

The increasing integration of AI in the invention process poses unique challenges to traditional patent law theories, prompting a debate on whether patents should be granted for AI-related inventions. Protection frameworks will shift their focus even more towards utilitarian theories, in particular the incentive theory. Under this framework, granting patents for AI-related inventions can be seen as a means to encourage investment in AI technologies and their applications, thereby fostering technological advancement. The theory further supports this perspective by emphasizing the need to safeguard the substantial resources invested in developing AI systems and their outputs. By providing legal protection for AI-related inventions, this approach aims to ensure that innovators can obtain the benefits of their investments, thus maintaining incentives for continued research and development in AI.

This work critiques the idea of abolishing patents for AI-related inventions, suggesting that flexible legal tools and a reconsideration of how patents are granted might better serve innovation. It calls for the development of a comprehensive framework for patents that accommodates AI-driven innovation. Patents play a pivotal role in encouraging the public disclosure of AI-related inventions. This public disclosure is critical for advancing commercialisation and ensuring innovation reaches the market. In specific industries, where patent protection holds a key role in business models, such as the pharmaceutical industry, the majority of expenses associated with an invention arise not from the initial discovery itself but from the subsequent development costs vital to transform an invention into a marketable product.

Arguments in favour of an *ad hoc* regulation for AI-related inventions might prove to be too specific, rendering it unable to keep pace with the rapid development of the technological assumptions on which it is based, and thus possibly becoming dysfunctional again in the near future. Additionally, significant practical problems would arise, particularly with regard to legal certainty, in drawing a boundary between AI-related and conventional inventions, which would

necessarily be required if special provisions for AI-related inventions were established. Therefore, it is the view of this work that it is more advantageous not to create special regulations for the categorization of AI-related inventions, but rather to adapt existing, technology-neutral patent laws to accommodate the peculiarities of AI-related inventions. This approach maintains the flexibility necessary to keep pace with innovation while avoiding the complexities and potential obsolescence associated with specialized regulations.

Thus, since this work is against establishing a new *sui generis* intellectual property system specifically for AI-related inventions, the alternative approach of adjusting existing patent law is favoured. To prevent potential applicants from resorting to alternative protection instruments that would not offer adequate legal safeguards or societal incentives for innovation through its disclosure, an expedited patent granting procedure should be introduced at the EPO. Thus, the introduction of a “two-track patent system” is favoured. It would allow applicants of “standard” (non)-AI related and AI-related inventions to choose between a “standard examination procedure” with a 20-year patent protection or an “expedited examination procedure” that grants protection for (only) five years but involves a faster review within six months. The examination within this framework would only be possible if the EPO is to be equipped with AI systems to assist in the examination process. Moreover, an option to extend or convert to standard patents under certain conditions can also be considered. In this framework certain fast-moving industries may prefer the expedited option to ensure rapid market entry and protection, although for a shorter period. Similarly, technology companies might also opt for the five-year protection, particularly for inventions related to fast-evolving areas like software or smartphone updates. Rather than relying on trade secrets to maintain a competitive advantage during lead times, companies could secure short-term patent protection. This approach would not only offer a competitive edge to the applicant but also serve the public interest by making the innovation publicly accessible sooner, enabling society to benefit from the disclosed knowledge. This two-track system could balance the need for rapid innovation in certain sectors with the broader goal of fostering the dissemination of technological advancements for public benefit.

While several *de lege ferenda* proposals regarding in particular Article 52(2)(c), Article 56, Article 83 EPC and Rule 42 Implementing Regulations of the EPC have been proposed throughout this work, the most pressing matters can already be implemented within the framework of existing law through updates to the EPO Guidelines. In particular, the issues surrounding the inventive step required for inventions relating to AI have a number of ramifications. Inventiveness is defined as what lies beyond the capabilities of a person skilled in the art, achievable through the development of the inventor’s skills and tools. As AI technology rapidly advances, the standards for what constitutes an inventive step are also evolving. If AI is not considered an ordinary tool and represents a unique choice by the inventor, it does not influence the criterion of inventiveness. However, as AI enhances the tools available for experimentation, the capabilities of the person skilled in the art also advance, making them more adept at solving technical problems and thereby raising the bar for inventiveness. Patent offices need to adapt their criteria to reflect the unique capabilities of AI, recognising that AI can facilitate breakthroughs that human practitioners might not foresee, thereby expanding the definition of inventive activity.

From a technical standpoint as of mid-2025, it is unclear whether and when AI will completely replace human inventors. If the inventive process is entirely handed over to AI in the distant future, human understanding of the technical field may become unnecessary. Since AI systems can analyse vast amounts of data and generate inventions that may be more inventive than those created by humans, this suggests a shift in the concept of the inventive step, potentially raising the threshold for what constitutes a non-obvious invention. One could argue that the inventive step criterion will no longer be essential if AI at some point will be able to invent on its own, without any human being involved in any step of the process, because the invention itself would serve as evidence of its inventiveness. It would be unlikely that a human would have come up with the same invention and the AI could have already checked the state of the art and relevant prior art during the invention process. It is currently uncertain when and if such a scenario will materialise.

Thus, the main aim of this work is to examine the impact of AI on the inventive step requirement under the EPC and in EPO practice. While AI can be beneficial for researchers to advance innovation, not every advancement leads to a patent and the inventive step requirement acts as a gatekeeper in this sense. For the time being, the main challenges related to AI regarding the inventive step regard the person skilled in the art, the state of the art and relevant prior art, and the sufficiency of disclosure.

The first challenge involves the need to redefine who constitutes a “person skilled in the art”. While revising Article 56 EPC *de lege ferenda* to explicitly include AI as part of the inventive step analysis is an option, the proposal of this work suggests that a more flexible approach *de lege lata*, such as updating the EPO Guidelines, might be better. The EPO Guidelines should reflect a comprehensive review of the current examination process and the way in which the assessment of the inventive step is carried out. They should embrace the use of AI in the inventive process while retaining the human element in the definition of the skilled person. A hybrid approach that considers both human oversight and contribution, and machine creativity and inventiveness should be considered.

The elaborated concept of a “Skilled Person 2.0” represents an evolution in how patent law considers the hypothetical person skilled in the art, particularly in the context of AI-related inventions. This updated notion retains the fundamental principle of a hypothetical natural person (or team) while incorporating the increasing prevalence of AI tools in various technical fields. This hybrid “Skilled Person 2.0” would include a person with AI-related knowledge, making use of AI technologies, or a team of experts that includes an AI specialist, if that use would have been expected from the average person in the field (or fields) to which the invention relates, at the relevant date. Thus, once AI becomes a standard research tool in a certain field, the person having ordinary skills in the art, who is presumed to be aware of all the pertinent prior art, should also be familiar with the use of an ordinary AI tool that is routine and not inherently inventive, and will be equipped with AI for evaluating the inventive step, regardless of whether applicants used it or not.

The ordinary AI tool is identified as an AI system that has already been disclosed in the prior art. As of 2025, the “Skilled Person 2.0” might be expected to use AI tools like “ChatGPT 4-o” in all fields and more sophisticated AI tools in fields where such tools have become standard

practice at the relevant date. With this knowledge, a skilled person would be better equipped to fairly evaluate the inventive step. If this AI typically produces the claimed invention, the path from the objective technical problem to the claimed solution would be shown for the skilled person. The presumption of an inventive step for the claimed invention would be rebutted. This would replace a demonstration of the claimed invention in the prior art. However, the prerequisite for such an argument is that a suitable AI was accessible to the skilled person before the priority date of the invention.

The EPO should select referenced algorithms for each year and clarify, that these can be used as “tools” by the skilled person if the patent was filed that year, independently on how the invention was generated and of the information in the patent disclosure and will be used by the patent examiners in the examination process. In the EPO’s patent examination process, it is essential to select multiple specific AI systems, such as “Chat ChatGPT 4-o,” rather than relying on hypothetical models. Evaluating multiple AI systems that are currently used in the relevant field is crucial for gaining a thorough understanding of both the state of the art and the capabilities of the “Skilled Person 2.0” at the relevant date. To achieve this, the EPO should form partnerships with key AI providers to ensure that the EPO has an accurate view of AI capabilities over time, enabling the examination of patents using the technology available at the relevant date. Moreover, the Guidelines should state how examiners are required to have a level of expertise in the use of AI or otherwise how an expert panel should be established to provide guidance on the use of AI in the examination process. Additionally, the EPO should develop its own in-house AI system that integrates all external AI systems it gains access to or collaborate with external AI providers. An automated process could then allow patent examiners to input the invention’s details and relevant date, helping to determine whether an AI system at that time could have conceived the same idea and thus make the invention obvious. Similar to how AI systems assist the pharmaceutical industry in screening drug candidates, they could also aid patent examiners in filtering out unpatentable applications, thereby reducing the workload for examiners. This strategy could greatly enhance the precision and relevance of patent examinations in the AI era, providing a more accurate determination of inventive step.

The second challenge pertains to the evaluation of the state of the art and relevant prior art in the context of AI inventions. The invention must represent a significant technical advancement over the state of the art. This means that the invention must go beyond what is already known in the field and provide a new and non-obvious solution to a technical problem. This requirement may *prima facie* be easier to satisfy for AI-related inventions, since AI has the potential to create innovative solutions to technical problems, such as improving the accuracy or speed of data processing or enabling new applications of machine learning and natural language processing.

The state of the art, defined under Article 54 EPC, includes all publicly available information before the filing date of a patent application. The prevalence of AI within a specific field is crucial in determining whether it should be considered part of the state of the art. As AI technology evolves rapidly, the body of knowledge that constitutes the state of the art is also expanding with the inclusion of AI-related knowledge, complicating the assessment of the inventive step since the person skilled in the art must now possess a deeper understanding of

both traditional and AI-driven methodologies. Given AI's ability to process and integrate information across various fields, information related to AI should always be considered prior art for inventions regardless of how they were invented. Patent examiners must navigate a landscape where AI-related inventions may build upon or diverge from existing technologies in unpredictable ways. If AI-related information is recognized as relevant prior art, it could lead to a broader understanding of what constitutes the state of the art, potentially impacting the patentability of new inventions. This shift may necessitate mandatory disclosure of AI-related inventions as prior art to provide patent examiners with the necessary context for evaluating inventive steps accurately.

Finally, the most interesting application of AI in the patent world is the prior art search itself, where statistically significant similarities between patent documents are identified. AI tools, while useful in prior art searches, do not replace human judgment and expertise. Still, AI technologies can facilitate the prior art search process. With the increasing number of patent applications filed online and stored in databases, AI tools can help patent examiners efficiently and accurately search for relevant prior art documents by analysing and comparing their content, language, technical features, and citation patterns. AI algorithms can analyse millions of patent documents in databases and identify statistically significant similarities and differences between them, allowing the AI system, human inventors and patent examiners to focus on the most relevant documents to assess the inventiveness of an invention. This would result in an acceleration of both the inventive process and the patent granting process, resulting in an earlier publication of patent applications. In this regard the EPO has already implemented such AI system to improve the efficiency of patent examinations, although its application seems to be primarily focused on searching patents, publications, and images, rather than directly examining patents.

The third challenge pertains to the sufficiency of disclosure according to Article 83 EPO and Rule 42(1)(c) Implementing Regulations of the EPC. The current patent application system assumes that inventions are created by human inventors, but there are no specific means to verify this assumption, except for trusting patent applicants in their disclosure.

Given that some applicants may disclose the use of AI in their invention descriptions, while others may omit such information despite using AI, the disclosure of AI involvement should not influence the assessment of the inventive step. The evaluation process, particularly the analysis conducted from the perspective of the person skilled in the art, should remain consistent across all inventions, irrespective of any disclosed use of AI. Once the skilled person is defined, the applicant's level of expertise becomes irrelevant in assessing the inventive step. If it is anticipated that the skilled person would employ AI tools as part of their routine activities, the inventive step should be evaluated based on a skilled person with access to AI, regardless of whether the applicant actually used AI in developing the invention. This approach ensures that the assessment remains objective and centred on the invention's technical contribution rather than the specific methodologies employed by the inventor.

However, this perspective intersects with the requirements of Article 83 EPC, which mandates that a patent application disclose the invention sufficiently clearly and completely for it to be carried out by a person skilled in the art. In the context of AI-related inventions, this may

necessitates a detailed description of the AI components, including the architecture of machine learning models and the characteristics of training datasets, to enable reproducibility of the claimed technical effect. Failure to provide such detailed disclosure can lead to objections based on insufficient disclosure.

Additionally, to tackle the “black box” problem in AI technology, one proposed solution is the introduction of a depository rule for AI models. This concept is similar to the existing practice by WIPO for microorganisms. Under this rule, applicants would provide key components of the AI model, such as the code, data, and results, in digital form. These deposited AI models would clarify how the AI functions, how the claimed AI tools are developed and used, and what the individual components represent. This method would help address the issues related to insufficient descriptions and ensure the patent meets requirements for written description, enablement, novelty, and utility. Additionally, the deposited models could serve as evidence in future patent infringement cases.

The updated EPO Guidelines now require disclosure of detailed information about training datasets and the characteristics necessary to replicate the claimed technical effect, adding complexity to sufficiency of disclosure and influencing the assessment of the inventive step. While the EPO Guidelines suggest that it may not always be necessary to disclose specific datasets, they require that any characteristics of the data essential for replicating the claimed technical effect must be disclosed. The effects of these updates are still to be seen. Therefore, while the use or non-use of AI by the applicant should not affect the inventive step assessment, it is imperative that the application provides sufficient technical detail to meet the disclosure requirements under Article 83 EPC. This ensures that the invention can be reliably reproduced and evaluated, maintaining the integrity and consistency of the patent examination process.

In general, this work suggests focussing less on the inventive process and more on the inventiveness of the invention. While the EPO Guidelines can include a potential requirement for the disclosure of the use of AI in the patent application to ensure that the examiner is aware of the role of AI in the inventive process, this is merely a help and should not affect the granting of a patent if the invention includes an inventive step. The patent system should prioritize evaluating the objective technical merits of an invention rather than focusing excessively on the process of invention or imposing burdensome disclosure requirements on inventors. In general, patent offices cannot solely rely on a difficult to enforce disclosure requirement, but also need to determine the common general knowledge of the skilled person to assess the status of AI as a normal tool in a specific field.

Consequently, the challenge lies in ensuring that patent examiners have access to the appropriate context and understanding of AI technologies to accurately assess whether an invention is truly inventive or merely an obvious extension of existing knowledge or use of AI. The disclosure of the inventive process should merely help patent examiners analyse the invention and have a better overview of the use of AI in the relevant field. If AI is known to be a standard tool in the relevant field, the patent examiner should apply a standard AI and publicly available tools to the examination, independently of the concrete use and disclosure of AI. To guarantee that examiners and applicants have the information and proficiency necessary to evaluate the inventive step of ideas related to AI, this may require continual education and

training. The assessment of the inventive step of AI-related innovations will require interdisciplinary skills because AI technology frequently integrates with other disciplines including computer science, statistics, and mathematics. Due to this, patent examiners with various backgrounds may work together more frequently and rely more on outside specialists.

To conclude, while deliberations regarding the appropriate approach and the potential amendments required for the EPC or its Implementing Regulations will inevitably consume a considerable amount of time, the proposed changes to the EPO Guidelines can be introduced throughout the next year. Being proactive in technology law, by anticipating and establishing a forward-thinking and suitable framework for emerging technologies, is widely regarded as advantageous. Proactively adapting the EPO Guidelines ensures that patent law remains ahead of technological advancements and patent protection remains attractive.

REFERENCES

All online sources in this thesis were last accessed on 31 July 2025.

Abbott, Ryan, 'Allow patents on AI-generated inventions – for the good of science' (2023) *Nature* 699.

Abbott, Ryan and Rothman, Elizabeth, 'IP Law in the Era of Generative AI' (2024) 36(8) *Amplify* 34.

Abbott, Ryan and Rothman, Elizabeth, 'AI-Generated Output and Intellectual Property Rights: Takeaways from the Artificial Inventor Project' (2023) 45(4) *European Intellectual Property Review* 215.

Abbott, Ryan, *The Reasonable Robot: Artificial Intelligence and the Law* (Cambridge University Press 2020).

Abbott, Ryan, 'Everything Is Obvious' (2018) 66(2) *UCLA Law Review* 1.

Abbott, Ryan, 'Hal the Inventor: Big Data and Its Use by Artificial Intelligence' in Cassidy R Sugimoto, Hamid Ekbil and Michael Mattioli (eds), *Big data is not a monolith* (MIT Press 2016) 187.

Abbott, Ryan, 'I Think, Therefore I Invent: Creative Computers and the Future of Patent Law' (2016) 57(4) *Boston College Law Review* 1079.

Abd-alrazaq, Alaa / AlSaad, Rawan / Alhuwail, Dari and Ahmed, Arfan et al., 'Large Language Models in Medical Education: Opportunities, Challenges, and Future Directions' (2023) 9 *JMIR Medical Education* 1.

Aboy, Mateo / Lath, Aparajita / Minssen, Timo and Liddell, Kathleen, 'The sufficiency of disclosure of AI inventions' (2024) 19(11) *Journal of Intellectual Property Law & Practice* 834.

Abramowicz, Michael, 'Orphan Business Models: Toward a New Form of Intellectual Property' (2010) 124 *Harvard Law Review* 1362.

Akhtar, Salman / Khan, Mohammad / Osama, Khwaja, 'Machine Learning Approaches to Rational Drug Design' in Singh (ed), *Computer-Aided Drug Design* (Springer Nature, Singapore 2020) 279.

Allen Newell and Herbert A Simon, 'Computer Science as Empirical Inquiry: Symbols and Search' (1976) 19(3) *Communications of the ACM* 113.

Allison, John R and Hunter, Starling D., 'On the Feasibility of Improving Patent Quality One Technology at a Time: The Case of Business Methods' (2006) 21(2) *Berkeley Technology Law Journal* 729.

Allison, John R and Tiller, Emerson H, 'The Business Method Patent Myth' (2003) 18 *Berkeley Technology Law Journal* 987.

Ammendola, Maurizio, *La Brevettabilità nella Convenzione di Monaco* (Giuffrè 1981).

Ann, Christoph, *Patentrecht* (Beck, Munich 2022).

Ann, Christoph, 'Patent Trolls - Menace or Myth?' in W P Waldeck and Pymont (eds), *Patents and Technological Progress in a Globalized World: Liber Amicorum Joseph Straus* (Springer, Berlin and Heidelberg 2009) 355.

Ann, Christoph, 'Die idealistische Wurzel des Schutzes geistiger Leistungen' (2004) *GRUR International* 597.

Apel, Simon and Kaulartz, Markus, 'Rechtlicher Schutz von Machine Learning-Modellen' (2020) *RDİ - Recht Digital* 24.

Arnold, Richard, 'Harmonization of European Patent Law' (2019) 14(9) *Journal of Intellectual Property Law & Practice* 657.

Arrow, Kenneth, 'Economic Welfare and the Allocation of Resources for Invention' in Universities-National Bureau Committee for Economic Research, Committee on Economic Growth of the Social Science Research Council, *The Rate and Direction of Inventive Activity: Economic and Social Factors* (Princeton University Press 1962) 609.

Asay, Clark D., 'Artificial Stupidity' (2019) 61(5) *William & Mary Law Review* 1187.

Asquith, Julian, 'AI Inventions and Sufficiency at the EPO' (Marks & Clerk, 18 December 2020) <https://www.marks-clerk.com/insights/articles/ai-inventions-and-sufficiency-at-the-epo/>.

Bac, Jo, *Artificial Intelligence: A Dependent Legal Person – An Evolutionary Step for the United States Patent Law* (Academia Press 2018).

Baldus, Oliver, 'Der Schutz von Erfindungen auf dem Gebiet der künstlichen Intelligenz' (2020) *Mitteilungen der deutschen Patentanwälte* 51.

Ballardini, Rosa M / He, Kan and Roos, Teemu, 'AI-Generated Content: Authorship and Inventorship in the Age of Artificial Intelligence' in T Pihlajarinne, J Vesala and O Honkkila (eds), *Online Distribution of Content in the EU* (Edward Elgar 2019) 117.

Banterle, Francesco, 'Ownership of Inventions Created by Artificial Intelligence' (2018) *AIDA - Annali Italiani del Diritto D'autore, della Cultura e dello Spettacolo* 1, <https://ssrn.com/abstract=3276702>.

Bartenbach, Kurt und Volz, Franz-Eugen, *Arbeitnehmererfindungsgesetz* (5th edn, Carl Heymanns, Cologne 2013).

Barton, John H, 'Non-obviousness' (2003) 43 *IDEA: The Journal of Law and Technology* 475.

Bauckhage, Christian, Fürnkranz, Johannes and Paaß, Gerhard, 'Vertrauenswürdigen, transparentes und robustes Maschinelles Lernen', in G Görz et al (eds.), *Handbuch der Künstlichen Intelligenz* (3rd edn, Oldenbourg Wissenschaftsverlag, München 2018) 569.

Bauer, Carsten, *Patente für Pflanzen - Motor des Fortschritts?* (Nomos, Baden-Baden 2020).

Beale, Charlotte, 'Fourth Industrial Revolution Technology Patents are Flourishing' (World Economic Forum, 11 December 2017) <https://www.weforum.org/agenda/2017/12/fourth-industrial-revolution-technology-patents-internet-things-smart-object>.

Bedford, Harry, 'EPO Guidelines 2025: What's Changing?' (Solve Intelligence, 7 February 2025) https://www.solveintelligence.com/blog/post/epo-guidelines-2025?utm_source=chatgpt.com.

Beier, Friedrich K, 'The inventive step in its historical development' (1986) *IIC - International Review of Intellectual Property and Competition Law* 301.

Beier, Friedrich K, 'Zur historischen Entwicklung des Erfordernisses der Erfindungshöhe' (1985) *GRUR Inland* 606.

Beier, Friedrich K und Straus, Joseph, 'Das Patentwesen und seine Informationsfunktion' (1977) *GRUR* 282.

Beier, Friedrich K, 'Die herkömmlichen Patentrechtstheorien und die sozialistische Konzeption des Erfinderrechts' (1970) *GRUR International* 1.

Belleflamme, Paul, 'Patents and Incentives to Innovate: Some Theoretical and Empirical Economic Evidence' (2006) 13(2) *Ethical Perspectives* 267.

Benanti, Paolo, 'La domanda: perché le A.I. sono così avanzate mentre i robot non hanno avuto lo stesso sviluppo?' (Corriere della Sera, 7 July 2023) https://www.corriere.it/sette/attualita/23_luglio_07/domanda-perche-ai-sono-cosi-avanzate-mentre-robot-non-hanno-avuto-stesso-sviluppo-4c9d5f3c-1a66-11ee-803d-db3b1d875840.shtml).

Ben-Ari, David / Frish, Yair, Lazovski / Adam, Eldan, Uriel et al., "'Danger, Will Robinson'?" Artificial Intelligence in the Practice of Law: An Analysis and Proof of Concept Experiment' (2017) 23(2) *Richmond Journal of Law & Technology* 3.

Bengi, Kemal and Heath, Christopher, 'Patents and Artificial Intelligence Inventions' in Christopher Heath, Anselm K Sanders and Anke Moerland (eds), *Intellectual Property Law and the Fourth Industrial Revolution* (Wolters Kluwer 2020) 127.

Benthall, Sebastian, ‘Bostrom’s Superintelligence: Definitions and Core Argument’ (Digifesto, 20 August 2015) <https://digifesto.com/2015/08/20/bostroms-superintelligence-definitions-and-core-argument/>.

Bently, Lionel / Sherman, Brad / Gangjee, Dev / Johnson, Phillip, *Intellectual Property Law* (5th edn, Oxford University Press 2018).

Berman, Bruce, ‘“All Prior Art” Algorithm Won’t Stop Bad Patents or Actors’ (IPcloseup, 6 June 2016) <https://ipcloseup.com/2016/06/06/all-prior-art-algorithm-wont-stop-bad-patents-or-actors/>.

Bernhardt, Wolfgang, *Die Bedeutung des Patentschutzes in der Industriegesellschaft* (Carl Heymanns, Cologne 1974).

Bianchini, Stefano / Müller, Moritz and Pelletier, Pierre, ‘Artificial Intelligence in Science: An Emerging General Method of Invention’ (2022) 51(10) *Research Policy* 104604.

Birss, Colin / Waugh, Andrew / Mitcheson, Tom / Campbell, Douglas et al., *Terrell on the Law of Patents* (19th edn, Sweet & Maxwell 2020).

Bleicher, Ariel, ‘Demystifying the Black Box That Is AI’ (Scientific American, 9 August 2017) <https://www.scientificamerican.com/article/demystifying-the-black-box-that-is-ai/>.

Blok, Peter, ‘The inventor’s new tool: artificial intelligence - how does it fit in the European patent system?’ (2017) 39(2) *European Intellectual Property Review* 69.

Bojić, Ljubiša / Cinelli, Matteo / Čulibrk, Dubravko and Boris Delibašić, ‘CERN for AI: A Theoretical Framework for Autonomous Simulation-Based Artificial Intelligence Testing and Alignment’ (2024) 12(1) *European Journal of Futures Research* 15.

Boldrin, Michele and Levine, David K, ‘The Case against Patents’ (2013) 27(1) *Journal of Economic Perspectives* 3.

Bonadio, Enrico / McDonagh, Luke and Dinev, Plamen, ‘Artificial Intelligence as Inventor: Exploring the Consequences for Patent Law’ (2021) 1 *Intellectual Property Quarterly* 48.

Booq, Rayan Y / Tawfik, Essam A / Alfassam, Haya A / Alfahad, Ahmed J et al. ‘Assessment of the Antibacterial Efficacy of Halicin Against Pathogenic Bacteria’ (2021) 10(12) *Antibiotics* 1480.

Borowska, Kasia, ‘He: What, How and Why of AI – Part 3’ (Forbes, 3 November 2020) <https://www.forbes.com/sites/kasiaborowska/2020/11/03/he-what-how-and-why-of-ai--part-3/?sh=741aad6c6a15>.

Bossung, Otto, ‘Die Rechtsnatur der Patenterteilung - Nach deutschem und ausländischem Recht’ (1958) *GRUR International* 286.

Bostrom, Nick, *Superintelligence: Paths, Dangers, Strategies* (Oxford University Press 2014).

Bostrom, Nick, 'How Long Before Superintelligence?' (1998) 2(1) *International Journal of Future Studies* 1.

Brambilla, Paolo, 'Che cos'è l'Artificial Intelligence Act in Europa?' (La mia finanza, 7 April 2023) <https://www.lamiafinanza.it/2023/04/che-cose-lartificial-intelligence-act-in-europa/>.

Bray, Oliver, 'UKIPO Releases New Guidance on Patentability of AI-Related Inventions' (Lexology, 17 January 2023) <https://www.lexology.com/library/detail.aspx?g=01c82e3d-ef6c-49cc-bc76-b3da07b5214b>.

Bria, Francesca, 'C'è una via etica alla IA: il nostro Claude più umano di ChatGpt' (La Repubblica, 27 April 2023).

Brinkhof, Jan, 'The European Challenge. On Judicial Reasoning and on Legal Research and Teaching' in D van Engelen (ed), *The European Challenge in On the Brink of European Patent Law* (Eleven International 2011) 127.

Brooks, Michael, 'Quantum computers: what are they good for?' (2023) 617 *Nature* 1.

Bulgaru, Iolanda, 'Pharma Industry in the Age of Artificial Intelligence: The Future is Bright' (Healthcare Weekly, 18 March 2019) <https://healthcareweekly.com/artificial-intelligence-in-pharmacology/>.

Burk, Dan L, 'AI Patents and the Self-Assembling Machine' (2021) 105 *Minnesota Law Review Headnotes* 301.

Burk, Dan L and Lemley, Mark A, *The Patent Crisis and How the Courts Can Solve It* (The University of Chicago Press 2009).

Burk, Dan L and Lemley, Mark A, 'Is Patent Law Technology-Specific?' 17(4) *Berkeley Technology Law Journal* (2002) 1155.

Bußmann, Sarah / Glasowski, Carolin / Niehaus, Michael and Stecher, Sarah, 'Die Schutzzfähigkeit von KI-Trainingsdaten *de lege lata*' (2022) *RDigital - Recht Digital* 391.

Campbell, Ian C, 'The Apple Card Doesn't Actually Discriminate Against Women, Investigators Say' (The Verge, 24 March 2021) <https://www.theverge.com/2021/3/23/22347127/goldman-sachs-apple-card-no-gender-discrimination>.

Cantu-Ortiz, Francisco J / Galeano, Nathalie / Garrido, Leonardo and Terashima-Marin, Hugo, 'An artificial intelligence educational strategy for the digital transformation' (2020) 14(42) *International Journal on Interactive Design and Manufacturing* 1, <https://doi.org/10.1007/s12008-020-00702-8>.

Castells, Manuel, *The Rise of the Network Society* (2nd edn, Wiley Blackwell 2010).

Celik, Emir M, 'How IP Struggles to Define AI-Generated Products and the Ownership Dilemma' (2020) 71(2) *Ankara Üniversitesi Hukuk Fakültesi Dergisi* 581.

Cellan-Jones, Rory, 'Parkinson's Diagnosis Set to Be Sped Up by Tencent's AI' (BBC News, 8 October 2018) <https://www.bbc.com/news/technology-45780755>.

Černiauskas, Julius, 'Understanding The 4 V's Of Big Data' (Forbes, 23 August 2022) <https://www.forbes.com/councils/forbestechcouncil/2022/08/23/understanding-the-4-vs-of-big-data/>.

Cerulla, Daniele, 'La Brevettabilità delle Invenzioni Realizzate dall'Intelligenza Artificiale' (PhD thesis, University of Pavia 2022) https://iris.unipv.it/retrieve/e1f104fd-5b69-8c6e-e053-1005fe0aa0dd/Tesi%20di%20dottorato_Daniele%20Cerulla.pdf.

Cheishvili, Archil, 'The Future of Artificial General Intelligence' (Forbes, 16 July 2021) <https://www.forbes.com/sites/forbestechcouncil/2021/07/16/the-future-of-artificial-general-intelligence/?sh=672b07783ba9>.

Chen, Angela, 'Can an AI Be an Inventor? Not Yet.' (MIT Technology Review, 8 January 2020) <https://www.technologyreview.com/2020/01/08/102298/ai-inventor-patent-dabus-intellectual-property-uk-european-patent-office-law/>.

Chen, Charoline, '23andMe Gives Pfizer Genetic Data in Startup's Growth Quest' (Bloomberg, 12 January 2015) <https://www.bloomberg.com/news/articles/2015-01-12/23andme-gives-pfizer-dna-data-as-startup-seeks-growth>.

Chen, Ying / Argentinis, Elenee and Weber, Griff, 'IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research' (2016) 38(4) *Clinical Therapeutics* 688.

Chiang, Tun-Jen, 'A Cost-Benefit Approach to Patent Obviousness' (2008) 82(1) *St John's Law Review* 39.

Chisum, Donald S, 'Patentability Under TRIPS: The Need for Uniformity' (2006) 2(1) *Indian Journal of Law and Technology* 1.

Choi, Jay P and Gerlach, Heiko, 'A Theory of Patent Portfolios' (2017) 9(1) *American Economic Journal: Microeconomics* 315.

Choo, Kenny / Greplova, Eliska / Fischer, Mark H / Neupert, Titus, *Machine Learning kompakt* (Springer Spektrum, Berlin and Heidelberg 2021).

Chuang, Ashley, 'Fixing the Failures of Software Patent Protection: Deterring Patent Trolling by Applying Industry-Specific Patentability Standards' (2006) 16 *Southern California Interdisciplinary Law Journal* 232.

Chun, Matthew, 'Artificial Intelligence for Drug Discovery: A New Frontier for Patent Law' (2024) 104 *Journal of the Patent and Trademark Office Society* 5.

Clarkson, Gavin and DeKorte, David, 'The Problem of Patent Thickets in Convergent Technologies' (2006) 1093(1) *Annals of the New York Academy of Sciences* 180.

Claydon, Jeanne M, 'The Question of Obviousness in the Windsurfer Decision' (1985) *European Intellectual Property Review* 218.

Clifford, Ralph D, 'Creativity Revisited' (2018) 59 *IDEA: The Journal of Law and Technology* 25.

Cockburn, Iain M / Henderson, Rebecca and Stern, Scott, 'The Impact of Artificial Intelligence on Innovation: An Exploratory Analysis' in A Agrawal, J Gans, and A Goldfarb, *The Economics of Artificial Intelligence: An Agenda* (The University of Chicago Press 2019).

Cohen, Julie E, *Between Truth and Power: The Legal Constructions of Informational Capitalism* (Oxford University Press 2019).

Colaianne, Anthony, '35 USC § 103: A Quest for Objectivity' (1981) *Intellectual Property Law Review* 212.

Cole, Jerry, 'AI and the Question of Consciousness: Can Machines Engage in Self-Inquiry?' (2025) *ResearchGate* 1,
https://www.researchgate.net/publication/391007117_AI_and_the_Question_of_Consciousness_Can_Machines_Engage_in_Self-Inquiry.

Cole, Paul, 'Inventive step-meaning of the EPO Problem and Solution Approach, and Implications for the United Kingdom - Part I' (1998) 20(6) *European Intellectual Property Review* 214.

Comer, Anna C, 'AI: Artificial inventor or the real deal?' (2021) 22(3) *North Carolina Journal of Law & Technology* 447.

Conrad, Kurt and Chambliss, Stephen, 'The Digital Crossroads: US Leadership at Stake in the Global Trade Arena' (The Hill, 2024) <https://thehill.com/opinion/4490251-the-digital-crossroads-us-leadership-at-stake-in-the-global-trade-arena/>.

Cookson, Clive, 'EU Project Launched to Prepare Health Workers for a Digital Future' (Financial Times, 5 March 2025) <https://www.ft.com/content/a56ef5a3-f5d8-446d-ae9b-f503cce20de7>.

Cornish, Kristina, 'Actavis v ICOS - The Supreme Court rules on Dosage Regimes' (Kilburn & Strode, 27 March 2019) <https://www.kilburnstrode.com/knowledge/european-ip/actavis-v-icos-the-supreme-court-rules>.

Cornish, William / Llewelyn, David and Aplin, Tanya, *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights* (9th edn, Sweet & Maxwell 2013).

Coulter, Martin, 'Patent agencies challenged to accept AI inventor' (Financial Times, 1 August 2019) <https://www.ft.com/content/9c114014-b373-11e9-bec9-fdcab53d6959>.

Council, Jared, 'Can an AI System Be Given a Patent?' (Wall Street Journal, 11 October 2019) <https://www.wsj.com/articles/can-an-ai-system-be-given-a-patent-11570801500>.

Crickmore, Connor, 'Year in Review: Artificial Intelligence at the EPO in 2022' (Reddie & Grose, 7 February 2023) <https://www.reddie.co.uk/2023/02/07/year-in-review-artificial-intelligence-at-the-epo-in-2022/>.

Cubert, Jeremy A and Bone, Richard GA, 'The Law of Intellectual Property Created by Artificial Intelligence' in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 414.

Cupitt, Philip, 'EPO Updates Guidelines for Examining AI Inventions' (The Patent Lawyer Magazine, 20 February 2024,) <https://patentlawyermagazine.com/epo-updates-guidelines-for-examining-ai-inventions/>.

Cuthbertson, Aidan, 'Artificial Intelligence Program ConceptNet Matches 4-Year-Old Child in IQ Test' (Int'l Business Times, 7 October 2015) <http://www.ibtimes.co.uk/artificial-intelligence-program-conceptnet-matches-4-year-old-child-iq-test-1522836>.

Damme, Felix, *Das Deutsche Patentrecht* (Kessinger, Berlin 1906).

Darrow, Jonathan J, 'The Neglected Dimension of Patent Law's PHOSITA Standard' (2009) 23 *Harvard Journal of Law & Technology* 227.

Dasgupta, Dipankar and Michalewicz, Zbigniew, 'Evolutionary Algorithms - An Overview' in D Dasgupta and Z Michalewicz (eds), *Evolutionary Algorithms in Engineering Applications* (Springer, Berlin and Heidelberg 1997) 3.

David J Teece, 'Profiting from Technological Innovation' (1986) 15(6) *Research Policy* 285.

Davies, Colin R, 'An Evolutionary Step in Intellectual Property Rights - Artificial Intelligence and Intellectual Property' (2011) 27(6) *Computer Law & Security Review* 601.

Davies, Nahla, 'How To Calculate Algorithm Efficiency' (KDnuggets, September 2022) <https://www.kdnuggets.com/2022/09/calculate-algorithm-efficiency.html>.

Davis, Richard / St Quintin, Thomas and Tritton, Guy, *Tritton on Intellectual Property in Europe* (5th edn, Sweet & Maxwell 2018).

de Lange, Douwe, 'EU Patent Harmonization Policy: Reconsidering the Consequences of the UPCA' (2021) 16(10) *Journal of Intellectual Property Law & Practice* 1078.

de Rassenfosse, Gaétan / Jaffe, Adam B and Wasserman, Melissa, 'AI-Generated Inventions: Implications for the Patent System' (2024) 96(6) *Southern California Law Review* 1453.

Demsetz, Harold, 'Toward a Theory of Property Rights' (1967) 57(2) *The American Economic Review* 347.

Denicolò, Vincenzo and Franzoni, Luigi A, 'The Contract Theory of Patents' (2003) 23 *International Review of Law & Economics* 365.

DeNisco Rayome, Alison, 'Demand for AI Talent Exploding: Here Are the 10 Most In-Demand Jobs' (TechRepublic, 1 March 2018,) <https://www.techrepublic.com/article/demand-for-ai-talent-exploding-here-are-the-10-most-in-demand-jobs/>.

Dent, Chris, 'An exploration of the principles, precepts and purposes that provide structure to the patent system' (2008) 4 *Intellectual Property Quarterly* 456.

Derclaye, Estelle and Leistner, Matthias, *Intellectual Property Overlaps: A European Perspective* (Hart Publishing 2011).

Derclaye, Estelle, 'The ECJ interprets the database sui generis right for the first time' (2005) 30 *European Law Review* 420.

Dhenne, Matthieu, 'T 161/18: Sufficiency of Disclosure Put to the Test of Artificial Intelligence' (Institut Boufflers, 4 September 2020) <https://www.institutboufflers.org/en/t-161-18-sufficiency-of-disclosure-put-to-the-test-of-artificial-intelligence-matthieu-dhenne/>.

Di Cataldo, Vincenzo, 'I brevetti per invenzione e per modello di utilità. I disegni e modelli' in P Schlesinger (ed), *Commentario al codice civile* (Giuffrè, Milan 2012) 16.

Di Cataldo, Vincenzo, *Le invenzioni. I modelli* (2 edn, Giuffrè, Milan 1993).

Di Cataldo, Vincenzo, *L'originalità dell'invenzione* (Giuffrè, Milan 1983).

Dietz, Adolf, 'Das Urhebervertragsrecht in seiner rechtspolitischen Bedeutung' in F K Beier (ed), *Urhebervertragsrecht. Festgabe für Gerhard Schricker zum 60. Geburtstag* (Beck, Munich 1995) 1.

Dilmegani, Cem and Ermut, Sila, 'When Will AGI/Singularity Happen? 8,590 Predictions Analyzed' (AI Multiple Research, 1 August 2025) <https://research.aimultiple.com/artificial-general-intelligence-singularity-timing/>.

DiMasi, Joseph A / Grabowski, Henry G and Hansen, Ronald W, 'Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs' (2016) 47 *Journal of Health Economics* 20.

Dimitrov, Tanja / Kreisbeck, Christoph / Becker, Jill S / Aspuru-Guzik, Alán, 'Autonomous Molecular Design: Then and Now' (2019) 11(28) *ACS Applied Materials & Interfaces* 24825.

Di, Wei / Wie, Jianing and Bhardwaj, Anurag, *Deep Learning Essentials: Your Hands-on Guide to the Fundamentals of Deep Learning and Neural Network Modeling* (Packt Publishing 2018).

Domingos, Pedro, *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World* (Basic Books 2015).

Donovan, Alexander, 'Tech Leaders Have Strong Opinions on Artificial Intelligence' (Interesting Engineering, 1 April 2020) <https://interestingengineering.com/innovation/tech-leaders-have-strong-opinions-on-artificial-intelligence>.

Dornis, Tim W, 'Of "Authorless Works" and "Inventions without Inventor"-The Muddy Waters of "AI Autonomy"' (2021) 43(9) *European Intellectual Property Review* 570.

Dornis, Tim W, 'Artificial Intelligence and Innovation: The End of Patent Law as We Know It' (2020) 23 *Yale Journal of Law & Technology* 97.

Dornis, Tim W, 'Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 1)' (2020) *Mitteilungen der deutschen Patentanwälte* 436.

Dornis, Tim W, 'Künstliche Intelligenz und Innovation - Perspektiven der Disruption im Patentrecht (Teil 2)' (2020) *Mitteilungen der deutschen Patentanwälte* 477.

Drexel Josef / Hilty, Reto / Kim, Daria / Slowinski, Peter R, 'Artificial Intelligence Systems as Inventors? A Position Statement of 7 September 2021 in view of the evolving case-law worldwide' (Max Planck Institute for Innovation and Competition Research Paper No. 21-20, 2021) <https://ssrn.com/abstract=3919588>.

Drexel, Josef / Hilty, Reto / Desaunettes-Barbero, Luc / Globocnik, Jure et al., 'Position Statement on IP Law and Artificial Intelligence' (Max Planck Institute for Innovation and Competition Research Paper No. 21-10, 9 April 2021) https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/MPI_PositionPaper__SSRN_21-10.pdf.

Drexel, Josef / Hilty, Reto / Desaunettes-Barbero, Luc / Globocnik, Jure et al., 'Comments of the Max Planck Institute for Innovation and Competition of 11 February 2020 on the Draft Issues Paper of the WIPO on Intellectual Property Policy and Artificial Intelligence' (2020) https://www.ip.mpg.de/fileadmin/ipmpg/content/stellungnahmen/2020-02-11_WIPO_AI_Draft_Issue_Paper__Comments_Max_Planck.pdf.

Drexel, Josef / Hilty, Reto / Beneke, Francisco / Desaunettes-Barbero, Luc et al., 'Technical Aspects of Artificial Intelligence: An Understanding from an Intellectual Property Law Perspective' (Max Planck Institute for Innovation & Competition Research Paper No. 19-13, 10 October 2019) <https://ssrn.com/abstract=3465577>.

Duch, Włodzisław / Swaminathan, Karthikeyan and Meller, Jarosław, 'Artificial Intelligence Approaches for Rational Drug Design and Discovery' (2007) 13(14) *Current Pharmaceutical Design* 1497.

Duhigg, Charles, 'How Companies Learn Your Secrets' (The New York Times, 16 February 2012) <https://www.nytimes.com/2012/02/19/magazine/shopping-habits.html>.

Duhigg, Charles, *The Power of Habit* (Random House 2012).

Dvorsky, George, 'Should Artificial Intelligence Be Credited as an Inventor?' *Gizmodo* (2 August 2019) <https://gizmodo.com/should-artificial-intelligence-be-credited-as-an-invent-1836920203>.

Dyer, Travis A / Glaser, Stephen / Lang, Mark H / Sprecher, Caroline, 'The Effect of Patent Disclosure Quality on Innovation' (2024) 77(2-3) *Journal of Accounting and Economics* 101647 <https://www.sciencedirect.com/science/article/pii/S016541012300071X>.

Ebers, Martin / Heinze, Christian / Krügel, Tina / Steinrötter, Björn (eds), *Künstliche Intelligenz und Robotik* (Beck, Munich 2020).

Ebert, Lawrence B, 'More on All Prior Art Database of Alexander Reben; the USPTO Responds (Sort of)' (IPbiz.blogspot, 12 April 2016) <http://ipbiz.blogspot.com/2016/04/more-on-on-all-prior-art-database-of.html>.

Ebrahim, Tabrez Y, 'Artificial Intelligence Inventions & Patent Disclosure' (2020) 125(1) *Penn State Law Review* 147.

Ebrahim, Tabrez Y, 'Data-Centric Technologies: Patent and Copyright Doctrinal Disruptions' (2019) 43(3) *Nova Law Review* 287.

Ehlers, Jochen / Husband, Ben / Kretschmer, Thomas / Potter, Julian et al., 'European Patent Office', in J P Osha, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023) 89.

Ehlich, Eva and Fujimoto, Naho, 'EPO Timelines - The EPO Speeds Up Patent Examination and Opposition' (Maiwald, April 2019) https://www.maiwald.eu/fileadmin/Download/PDF/2019-04_NF_EPO_Timelines.pdf.

Eifert, Martin and Hoffmann-Riem, Wolfgang, *Geistiges Eigentum und Innovation: Bestandsaufnahme und Perspektiven* (Nomos, Baden-Baden 2004).

Eisenberg, Anne, 'What's Next: When a Gizmo Can Invent a Gizmo' (New York Times, 25 November 1999) <https://www.nytimes.com/1999/11/25/technology/what-s-next-when-a-gizmo-can-invent-a-gizmo.html>.

Eisenberg, Rebecca S, 'Obvious to Whom? Evaluating Inventions from the Perspective of PHOSITA' (2004) 19(3) *Berkeley Technology Law Journal* 885.

Engel, Andreas, 'Erfinderische Tätigkeit und Künstliche Intelligenz' (2022) *GRUR* 864.

Engel, Andreas, 'Can a Patent Be Granted for an AI-Generated Invention?' (2020) *GRUR International* 1123.

England, Paul, *A Practitioner's Guide to European Patent Law: For National Practice and the Unified Patent Court* (Hart 2019).

England, Paul, 'Obvious to Try, One Year On' (2009) 4(2) *Journal of Intellectual Property Law & Practice* 114.

Escott, Eban, 'The 3 Types of AI: Is the Third Even Possible?' (Codebots, 24 October 2017) <https://codebots.com/artificial-intelligence/the-3-types-of-ai-is-the-third-even-possible>.

Fabris, Daniele, 'From the PHOSITA to the MOSITA: Will "Secondary Considerations" Save Pharmaceutical Patents from Artificial Intelligence?' (2020) *IIC -International Review of Intellectual Property and Competition Law* 685.

Faggella, Daniel, 'Machine Learning Drug Discovery Applications - Pfizer, Roche, GSK, and More' (Emerj, Business Intelligence and Analytics, 2 February 2019) <https://emerj.com/ai-sector-overviews/machine-learning-drug-discovery-applications-pfizer-roche-gsk/>.

Fenwick, Mark / Kaal, Wulf and Vermeulen, Erik P M, 'Regulation Tomorrow: What Happens When Technology is Faster than the Law' (2017) 6 *American Business Law Review* 561.

Ferrari, Enrico and Muselli, Marco, 'Efficient Constructive Techniques for Training Switching Neural Networks' in L Franco, J M Jerez et al. (eds), *Constructive Neural Networks* (Springer, Berlin and Heidelberg 2009) 25.

Ferrucci, David / Brown, Eric / Chu-Carroll, Jennifer / Fan, James et al., 'Building Watson: An Overview of the DeepQA Project' (2010) 31(3) *AI Magazine* 59.

Fischer, Michael M, 'Revisiting G 1/19 Three Years Later: A Missed Opportunity?' (2025) *GRUR International* 48.

Fischer, Michael M, 'The Problem and Solution Approach – Basic Case Law and Recent Development (II)' (2016) *epi (European Patent Institute) Information* <https://information.patentepi.org/4-16/the-problem-and-solution-approach-basic-case-law-and-recent-development-%28ii%29/>.

Fisher, M J, 'Classical Economics and Philosophy of the Patent System' (2005) 1 *Intellectual Property Quarterly* 1.

Fisher, William W, 'Theories of Intellectual Property' in S Munzer (ed.), *New Essays in the Legal and Political Theory of Property* (Cambridge University Press 2001) 169.

Fitzner, Uwe / Metzger, Alex, 'PatG § 3' in U Fitzner, S Kubis und T Bodewig, *Beck'scher Online-Kommentar Patentrecht* (Beck, Munich 2023).

Fleming, Nic, 'How Artificial Intelligence is Changing Drug Discovery' (2018) 557 *Nature* 55.

Floridi, Luciano, *The Fourth Revolution: How the Infosphere is Reshaping Human Reality* (Oxford University Press 2014) 129.

Florida, Giorgio, 'I requisiti di proteggibilità' in P Auteri et al. (eds), *Diritto industriale: proprietà intellettuale e concorrenza* (Giappelli Editore, Turin 2020) 267.

Fountaine, Tim / McCarthy, Brian and Saleh, Tamim, 'Building the AI-Powered Organization' (2019) 97 *Harvard Business Review* 62.

Franzosi, Mario, 'I requisiti di brevettabilità' in M Franzosi and M Scuffi (eds), *Diritto industriale italiano* (Wolters Kluwer, Padova 2014) 323.

Franzosi, Mario, 'Non ovvietà' in *Studi di diritto industriale in onore di Adriano Vanzetti* (Giuffrè, Milan 2004) 474.

Fraser, Erica, 'Computers as Inventors - Legal and Policy Implications of Artificial Intelligence on Patent Law' (2016) 13(3) *SCRIPTed – A Journal of Law, Technology & Society* 305.

Frey, Carl B and Osborne, Michael, *The Future of Employment: How Susceptible are Jobs to Computerisation?* (Oxford University Press 2013).

Fromer, Jeanne C, 'Patent Disclosure' (2008) 94 *Iowa Law Review* 539.

Fruscalzo, Riccardo, 'Il carattere tecnico dell'invenzione' (PhD thesis, University of Parma 2013) <https://www.repository.unipr.it/handle/1889/2148>.

Frynas G, Jędrzej / Mellahi, Kamel and Pigman A, Geoffrey, 'First Mover Advantage in International Business and Firm-Specific Political Resources' (2006) 27(4) *Strategic Management Journal* 321.

Füchsle, Kathrin and Bausch, Thorsten, 'The Problem of the "Closest Prior Art"' (Kluwer Patent Blog, 24 June 2020) <https://patentblog.kluweriplaw.com/2020/06/24/the-problem-of-the-closest-prior-art/>.

Fujii, Hidemichi and Managi, Shunsuke, 'Trends and Priority Shifts in Artificial Intelligence Technology Invention: A global patent analysis' (2017) *Economic Analysis and Policy*, Elsevier 60.

Fumo, Jose, 'Types of Machine Learning Algorithms You Should Know' (Towards Data Science, 2020) <https://towardsdatascience.com/types-of-machine-learning-algorithms-you-should-know-953a08248861>.

Galli, Cesare, 'Intelligenza artificiale, ricerca e brevetti: cosa sta cambiando e le norme che servono' (Agenda Digitale, 13 January 2020) <https://www.agendadigitale.eu/cultura-digitale/intelligenza-artificiale-ricerca-e-brevetti-cosa-sta-cambiando-e-le-norme-che-servono/>.

Galli, Cesare, 'Per un Approccio Realistico al Diritto dei Brevetti' (2010) *Il Diritto Industriale* 133.

Galli, Cesare and Bogni, Mariangela, 'Intelligenza artificiale, nuove dinamiche della ricerca e problem and solution approach' (2020) *Il Diritto industriale* 127.

Galli, Cesare and Bogni, Mariangela, 'Il requisito di brevettabilità dell'attività inventiva', in C Galli and A Gambino (eds), *Codice Commentato della Proprietà Industriale ed Intellettuale* (UTET, Turin 2011) 578.

Gambardella, Alfonso / Harhoff, Dietmar and Verspagen, Bart, 'The Economic Value of Patent Portfolios' (2017) 26(4) *Journal of Economics & Management Strategy* 735.

Gambrell, James B and Dodge, John H, 'Ordinary Skill in the Art - An Enemy of the Inventor or a Friend of the People?' in John F Witherspoon (ed), *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs, Washington 1979).

Gärtner, Anette, 'Künstliche Intelligenz als Erfinder - oder: Stanley K. lässt grüßen' (2022) *GRUR* 207.

Gates, Christina, 'Patenting the Life Sciences at the European Patent Office' (2014) 4(12) *Cold Spring Harbor Perspectives in Medicine* 1.

Gavine, Adam, 'AI Tool Set Underway for Aircraft Design and Certification' (Aircraft Interiors International, 21 May 2020) <https://www.aircraftinteriorsinternational.com/news/mro/ai-tool-set-underway-for-aircraft-design-and-certification.html>.

Gelernter, David, 'Machines That Will Think and Feel: Artificial Intelligence is still in its Infancy - and that should scare us' (The Wall Street Journal, 18 March 2016) <https://www.wsj.com/articles/when-machines-think-and-feel-1458311760>.

George, Alexandra and Walsh, Toby, 'Can AI Invent?' (2022) 4(12) *Nature Machine Intelligence* 1057.

Géron, Aurélien, *Machine Learning mit Scikit-Learn & TensorFlow* (2nd edn, O'Reilly 2020).

Gervais, Daniel, 'Exploring the Interfaces Between Big Data and Intellectual Property Law' (2019) 10 *Journal of Intellectual Property, Information Technology and Electronic Commerce Law* 22.

Ghahramani, Zoubin, 'Probabilistic Machine Learning and Artificial Intelligence' (2015) 521(7552) *Nature* 452.

Ghidini, Gustavo and De Benedetti, Fabrizio, *Codice della Proprietà Industriale - Commento alla normativa sui diritti derivanti da registrazione e brevettazione* (Giuffrè, Milan 2006).

Gianni, Manuela, 'McKinsey Stima il Ritorno degli Investimenti in AI: "Potenziale Raddoppio del Cash Flow Entro il 2030"' (Digital4Executive, 19 November 2018) <https://www.digital4.biz/executive/digital-transformation/mckinsey-intelligenza-artificiale-ritorno-investimenti/>.

Gibson, Johanna, 'Artificial intelligence and patents: DABUS and methods for attracting enhanced attention to inventors' 11(4) *Queen Mary Journal of Intellectual Property* 401.

Gigerenzer, Gerd, 'Certainty as an Illusion: We Should Learn to Live Without It' (Philonomist, 29 May 2024) <https://www.philonomist.com/en/entretien/certainty-illusion-we-should-learn-live-without>.

Gigerenzer, Gerd, *How to Stay Smart in a Smart World: Why Human Intelligence Still Beats Algorithms* (The MIT Press 2022).

Gilliam-Scott, Caleb, 'Updated EPO Guidelines Impact AI Disclosure' (Pearl Cohen, 2024) <https://www.pearlcohen.com/updated-epo-guidelines-impact-ai-disclosure/>.

Ginac, Frank, 'The Impossible Goal: Bias-Free AI' (IHRIM, 15 September 2021) <https://www.ihrim.org/2021/09/the-impossible-goal-bias-free-ai-by-frank-ginac/>.

Girasa, Rosario, *Artificial Intelligence as a Disruptive Technology* (Palgrave MacMillan 2020).

Godt, Christine, *Eigentum an Information* (Mohr Siebeck, Tübingen 2007).

Goldman, Eric, 'Fixing Software Patents' (Santa Clara University School of Law, January 2013) <https://digitalcommons.law.scu.edu/facpubs/596>.

Gonzalez Torres, Ana P, 'AI-generated inventions: (A)I, inventor?' (IusItinere, 27 April 2022) https://www.iusinitinere.it/ai-generated-inventions-ai-inventor-42263#_ftn9.

Good, Irving J, 'Speculations Concerning the First Ultraintelligent Machine' in F Alt and M Ruminoff (eds), *Advances in Computers* (vol 6, Academic Press 1965).

Goode, Lauren, 'Google CEO Sundar Pichai compares impact of AI to electricity and fire' (The Verge, 19 January 2018) <https://www.theverge.com/2018/1/19/16911354/google-ceo-sundar-pichai-ai-artificial-intelligence-fire-electricity-jobs-cancer>.

Goodfellow, Ian / Pouget-Abadie, Jean / Mirza, Mehdi / Xu, Bing et al., 'Generative Adversarial Nets' 3(11) *Advances in Neural Information Processing Systems* 2672.

Gormley, Brian, 'Companies Bring AI Agents to Healthcare' (The Wall Street Journal, 27 February 2025) <https://www.wsj.com/articles/companies-bring-ai-agents-to-healthcare-cf9f49c1>.

Gottfredson, Linda S, 'Mainstream Science on Intelligence: An Editorial With 52 Signatories, History and Bibliography' 24(1) *Intelligence* 13.

Grafstein, Robert, *Institutional Realism: Social and Political Constraints on Rational Actors* (Yale University Press 1992).

Graham Oppy and David Dowe, 'The Turing Test' (2021) *The Stanford Encyclopedia of Philosophy* <https://plato.stanford.edu/entries/turing-test/>.

Graham, Stuart J H and Hegde, Deepak, 'Do Inventors Value Secrecy in Patenting? Evidence from the American Inventors Protection Act of 1999' (2015) 61 *Management Science* 1190.

Granstrand, Ove, 'Are We on Our Way in the New Economy with Optimal Inventive Steps?' (2003) *Economics, Law and Intellectual Property* 223.

Greenberg, Anastasia, 'Protecting Virtual Things: Patentability of Artificial Intelligence Technology for the Internet of Things' (2020) 60(2) *IDEA: The Journal of Law and Technology* 328.

Guarda, Paolo and Trevisanello, Laura, 'Robots as artists, robots as inventors, is the intellectual property rights world ready?' (2021) 43(11) *European Intellectual Property Review* 740.

Guidotti, Riccardo / Monreale, Anna / Giannotti, Fosca / Pedreschi, Dino et al., 'Factual and Counterfactual Explanations for Black Box Decision Making' (2019) 34(6) *IEEE Intelligent Systems Journal* 14.

Gurgula, Olga, 'AI-Assisted Inventions in the Field of Drug Discovery: Readjusting the Inventive Step Analysis' (2020) 2(8) *International Journal of Social Science and Public Policy* 2.

Gurgula, Olga, 'Strategic Accumulation of Patents in the Pharmaceutical Industry and Patent Thickets in Complex Technologies – Two Different Concepts Sharing Similar Features' (2017) *IIC - International Review of Intellectual Property and Competition Law* 385.

Hacker, Philipp, 'Immaterialgüterrechtlicher Schutz von KI-Trainingsdaten' (2020) *GRUR* 1025.

Hall, Bronwyn H and Ziedonis, Rosemarie H, 'The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry, 1979-1995' (2001) 32 *RAND Journal of Economics* 101.

Hao, Karen, 'This is how AI bias really happens - and why it's so hard to fix' (MIT Technology Review, 4 February 2019) <https://www.technologyreview.com/2019/02/04/137602/this-is-how-ai-bias-really-happensand-why-its-so-hard-to-fix/>.

Hardin, Garrett, 'The Tragedy of the Commons' (1968) 162 *Science* 1243.

Hartmann, Christian et al., 'Trends and Developments in AI. Challenges to the Intellectual Property Rights Framework. Final Report' (Publications Office of the European Union, 2020) https://www.ivir.nl/publicaties/download/Trends_and_Developments_in_Artificial_Intelligence-1.pdf.

Hartzog, Wodrow / Conti, Gregory / Nelson, John / Shay, Lisa A, 'Inefficiently Automated Law Enforcement' (2015) *Michigan State Law Review* 1763.

Hassan, Sandro, 'Descrizione brevettuale ed esposizione del problema tecnico' (2014) *Rivista di diritto industriale* 113.

Hattenbach, Ben and Snyder, Gavin, 'Rethinking the Mental Steps Doctrine and Other Barriers to Patentability of Artificial Intelligence' (2018) 19(2) *Columbia Science and Technology Law Review* 313.

Hattenbach, Ben and Glucoft, Joshua, 'Patents in an Era of Infinite Monkeys and Artificial Intelligence' (2015) 19 *Stanford Technology Law Review* 32.

Haucap, Justus and Dewenter, Ralf, *First-Mover Vorteile im Schweizer Mobilfunk* (HSU, Hamburg 2006).

Hauck, Ronny and Cevc, Baltasar, 'Patentschutz für Systeme Künstlicher Intelligenz' (2019) *Zeitschrift für Geistiges Eigentum* 135.

Hauser, Marc, *The Evolution of Communication* (MIT Press 2000).

Heggen, Alfred, *Erfindungsschutz und Industrialisierung in Preußen* (GESIS, Mannheim und Köln 2008).

Heikkilä, Melissa, 'Generative AI Risks Concentrating Big Tech's Power: Here's How to Stop It' (MIT Technology Review, 18 April 2023) <https://www.technologyreview.com/2023/04/18/1071727/generative-ai-risks-concentrating-big-techs-power-heres-how-to-stop-it/>.

Heikkilä, Melissa and Heaven, Will Douglas, 'What's Next for AI' (MIT Technology Review, 23 December 2022) <https://www.technologyreview.com/2022/12/23/1065852/whats-next-for-ai/>.

Heller, Michael A and Eisenberg, Rebecca S, 'Can Patents Deter Innovation? The Anticommons in Biomedical Research' (1998) 280 *Science* 698.

Heribert Burghartz, *Technische Standards, Patente und Wettbewerb* (Duncker & Humblot, Berlin 2011).

Hervey, Matt / Driver, Virginia and Woodhouse, Tom, 'Intellectual Property' in M Hervey and M Lavy (eds), *The Law of Artificial Intelligence* (Sweet & Maxwell 2020).

Hetmank, Sven and Lauber-Rönsberg, Anne, 'Künstliche Intelligenz – Herausforderungen für das Immaterialgüterrecht' (2018) *GRUR* 574.

Hewel, Christoph, 'Navigating AI Patents Under Art. 83 EPC: Lessons from EPO Decision T 1669/21 on Sufficient Disclosure and Blackbox AI Protection' (Paustian & Partner, 1 December 2024) <https://www.paustian.de/navigating-ai-patents-under-art-83-epc-lessons-from-epo-decision-t-1669-21-on-sufficient-disclosure-and-blackbox-ai-protection/>.

Hickman, Steve, 'Reinventing Invention: Why Changing How We Invent Will Change What We Patent and What to Do About It' (2009) 91(2) *Journal of the Patent and Trademark Office Society* 108.

Higashihira, Shota / Simpson, Stefanie J / Collier, Christopher D / Natoli, Roman M et al., 'Halicin Is Effective Against Staphylococcus aureus Biofilms In Vitro' (2022) 480(8) *Clinical Orthopaedics and Related Research* 1476.

Hilty, Reto / Hoffmann, Jörg and Scheuerer, Stefan, 'Intellectual Property Justification for Artificial Intelligence' (Max Planck Institute for Innovation and Competition Research Paper No. 20-02, 24 February 2020) <https://ssrn.com/abstract=3539406>.

Hinton, Geoffrey E and Salakhutdinov, Ruslan R, 'Reducing the Dimensionality of Data with Neural Networks' (2006) 313 *Science* 504.

Hirashima, Ryuta, 'New Issues in patent law brought about by inventions related to machine learning and deep learning' (2020) 23 *PATENT* 163.

Hoekstra, Jelle, *Methodology for Paper C - Training for the European Qualifying Examination* (Deltapatents 2009).

Hope, Tom / Chan, Joel / Kittur, Aniket and Shahaf, Dafna, 'Accelerating Innovation through Analogy Mining' in S Matwin, S Yu, F Farood (eds), *KDD'17: Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (Association of Computing Machinery 2017) 235.

Hornby, Gregory / Globus, Al / Linden, Derek S / Lohn, Jason D, 'Automated Antenna Design with Evolutionary Algorithms' (2006) *Space* 1, <https://arc.aiaa.org/doi/10.2514/6.2006-7242>.

Horns, Axel, 'Der Patentschutz für softwarebezogene Erfindungen im Verhältnis zur „Open Source“-Software' (2000) *Internet Zeitschrift für Recht und Informatik* 1.

Hosie, Spencer, 'Patent Trolls and the New Tort Reform: A Practitioner's Perspective' (2008) 4(1) *I/S: A Journal of Law and Policy for the Information Society* 75.

Hoss, Alexandra, *Deceptive Conducts before the Patent Office: Challenges for Patent Law and Competition Law* (MIPLC Studies, Baden-Baden 2019).

Hou, Stephen, 'International Patent Office Guidance on Artificial Intelligence Inventions' (Solve Intelligence, 15 May 2024) <https://www.solveintelligence.com/blog-posts/international-patent-office-guidance-on-artificial-intelligence-inventions>.

Hu, Albert and Png, Ivan, 'Patent Rights and Economic Growth: Evidence from Cross-Country Panels of Manufacturing Industries' (2013) 65(3) *Oxford Economic Papers* 675.

Hugenholtz, Bernt and Quintais, João P, 'Copyright and Artificial Creation: Does EU Copyright Law Protect AI-Assisted Output?' (2021) *IIC - International Review of Intellectual Property and Competition Law* 1190.

Hugenholtz, Bernt, Quintais, João P and Gervais, Daniel, '[Guest Post] Study on Trends and Developments in Artificial Intelligence: Challenges to the IPR Framework' (The IPKat, 9 December 2020) <https://ipkitten.blogspot.com/2020/12/guest-post-study-on-trends-and.html>.

Hughes, Jane P / Rees, S / Kalindijan S B / Philpott, K L et al., 'Principles of Early Drug Discovery' (2011) 162(6) *British Journal of Pharmacology* 1239.

Hughes, Justin, 'The Philosophy of Intellectual Property' (1988) 77 *The Georgetown Law Journal* 287.

Hughes, Rose, 'An LLM is not (yet) a person skilled in the art (T 1193/23)' (IPKat, 19 May 2025) https://ipkitten.blogspot.com/2025/05/an-llm-is-not-yet-person-skilled-in-art.html?utm_source=chatgpt.com.

Hughes, Rose, 'Is it time to move on from the AI inventor debate?' (IPKat, 2 December 2020) <https://ipkitten.blogspot.com/2020/12/is-it-time-to-move-on-from-ai-inventor.html>.

Hunter, Jackie, 'Adopting AI is essential for a sustainable pharma industry' (2016) *Drug Discovery World* 69.

Hussain, Zubair et al., 'Study on Antibacterial Effect of Halicin (SU3327) against *Enterococcus faecalis* and *Enterococcus faecium*' (2022) 80(1) *Pathogens and Disease* ftac037.

Hüttermann, Aloys, 'Inventive step at the UPC – much ado about nothing (new)?' (Kluwer Patent Blog, 3 June 2025) <https://legalblogs.wolterskluwer.com/patent-blog/inventive-step-at-the-upc-much-ado-about-nothing-new>.

Iaia, Vincenzo, 'Le Invenzioni. L'oggetto e i Requisiti di Brevettazione' in F Genovese and G Olivieri (eds), *Proprietà Intellettuale* (UTET 2021).

Ihde, Aaron J, 'The Inevitability of Scientific Discovery' (1948) 67(6) *Scientific Monthly* 427.

Internet Association et al., 'Comments on Patenting Artificial Intelligence Inventions' (USPTO, 8 November 2019) https://www.uspto.gov/sites/default/files/documents/Internet%20Association_RFC-84-FR-44889.pdf.

Ireland, Imogen, 'The Skilled Machines Disrupting Drug Design' (Hogan Lovells Publications, October 2019) <https://www.hoganlovells.com/en/publications/the-skilled-machines-disrupting-drug-design>).

Isay, Rudolf, *Patentgesetz und Gesetz, betreffend den Schutz von Gebrauchsmustern* (4th ed., Berlin 1926).

Jaen, Nayna, 'Determining what AI data you need and how to source it' (RWS, 8 April 2024) <https://www.rws.com/artificial-intelligence/train-ai-data-services/blog/determining-ai-data-needs-and-sourcing/>.

Jaffe, Adam B and Lerner, Josh, *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It* (2004).

Johnson, Phillip, ‘Article 56 EPC’, in R Hacon and J Pagenberg (eds.), *Concise European Patent Law* (2nd ed., Wolters Kluwer, 2008) 52.

Jones, Gemma, ‘Amgen Signs Real World Study and Mobile Data Partnership’ (PMLiVE, 4 September 2017) http://www.pmlive.com/pharma_news/amgen_real_world_study_and_mobile_data_partnership_1203895.

Josef Bajada, ‘Artificial Intelligence Demystified’ (Towards Data Science, 2019) <https://towardsdatascience.com/https-medium-com-josef-bajada-demystifying-artificial-intelligence-6f5f7a8dd1b0>).

Kalyan, Katikapalli S, ‘A Survey of GPT-3 Family Large Language Models Including ChatGPT and GPT-4’ (2023) *arXiv* <https://doi.org/10.48550/arXiv.2310.12321>.

Kaplan, Jerry, *Intelligenza artificiale: Guida al futuro prossimo* (Luiss, Rome, 2017).

Karkhanis, Aashish R and Parenti, Jenna L, ‘Toward an Automated First Impression on Patent Claim Validity: Algorithmically Associating Claim Language with Specific Rules of Law’ (2016) 19 *Stanford Technology Law Review* 196.

Karlhuber, Mathias, ‘Das Einheitliche Patentgericht – ein Erfolg? Eine Einführung und Zwischenbilanz nach knapp zwei Jahren Praxis’ (IIC Germany, 5 June 2025) <https://www.iccgermany.de/magazin-post/das-einheitliche-patentgericht-ein-erfolg>.

Kashoki, Mwango / Hanaizi, Zahara / Yordanova, Stella / Vesely, Richheard et al., ‘A Comparison of EMA and FDA Decisions for New Drug Marketing Applications 2014-2016: Concordance, Discordance, and Why’ (2020) 107(1) *Clinical Pharmacology & Therapeutics* 195.

Kayton, Irving R, ‘Nonobviousness of the Novel Invention - 35 USC § 103’ in J F Witherspoon (ed), *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs, Washington 1979).

Keats, John, ‘John Koza Has Built an Invention Machine’ (Popular Science, 1 May 2006) <https://www.popsci.com/scitech/article/2006-04/john-koza-has-built-invention-machine/>.

Kelion, Leo, ‘AI System “Should Be Recognized as Inventor”’ (BBC, 1 August 2019) <https://www.bbc.com/news/technology-49191645>.

Kennington, A, ‘A Review of the “Problem and Solution” Approach to Inventive Step under Article 56 EPC’ (2016) *epi (European Patent Institute) Information* 28.

Keshavarzi Arshadi, Arash / Webb, Julia / Salem, Milad / Cruz, Emmanuel et al., ‘Artificial Intelligence for COVID-19 Drug Discovery and Vaccine Development’ (2020) 3 *Frontiers in Artificial Intelligence* 65.

Keussen, Christoph, 'Articles 1-6 Translation Regulation' in W Tilmann and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (Oxford University Press 2018).

Keynes, John M, 'Economic Possibilities for our Grandchildren' (1930), reprinted in *Essays in Persuasion* (Macmillan 1931).

Khalil, Hanan / Ameen, Daniel and Zarnegar, Armita, 'Tools to Support the Automation of Systematic Reviews: A Scoping Review' (2022) 144 *Journal of Clinical Epidemiology* 22.

Khoo Yi, Ivan and Fang Hao Sen, Andrew, 'The Rise and Application of Artificial Intelligence in Healthcare' in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence and Intellectual Property* (Oxford University Press 2021) 28.

Kica, Evisa and Groenendijk, Nico, 'The European patent system: dealing with emerging technologies' (2011) 24(1-2) *Innovation: The European Journal of Social Science Research* 85.

Kiebish, Michael A / Shah, Punit / Sarangarajan, Rangaprasad / Vishnudas, Vivek K et al., 'Bayesian Model Infers Drug Repurposing Candidates for Treatment of COVID-19' (2021) 11(6) *Applied Sciences* 2466.

Kiesewetter-Köbinger, Swen, 'Über die Patentierung von Programmen für Datenverarbeitungsanlagen' (2001) *GRUR* 185.

Kilchenmann, Christoph, *Patentschutz und Innovation: Eine ökonomische Analyse aus globaler und nationaler Sicht* (Peter Lang, Frankfurt 2011).

Kilkenny, Monique F and Robinson, Kerin M, 'Data Quality: "Garbage in - Garbage out"' (2018) 47(3) *Health Information Management Journal* 103.

Kim, Daria, 'On Words That Come Easy' (2023) *GRUR International* 433.

Kim, Daria / Alber, Maximilian / Kwok, Man W / Mitrovic, Jelena, 'Clarifying Assumptions About Artificial Intelligence Before Revolutionising Patent Law' (2022) *GRUR International* 293.

Kim, Daria / Alber, Maximilian / Kwok, Man W / Mitrovic, Jelena et al., 'Ten Assumptions About Artificial Intelligence That Can Mislead Patent Law Analysis' (Max Planck Institute for Innovation & Competition Research Paper No. 21-18, 2021) <https://ssrn.com/abstract=3910332>.

Kim, Daria, *Access to Non-Summary Clinical Trial Data for Research Purposes Under EU Law* (Springer, Berlin and Heidelberg 2021).

Kim, Daria, 'AI-Generated Inventions: Time to Get the Record Straight?' (2020) *GRUR International* 443.

King, Ross D / Rowland, Jem J / Aubrey, Wayne / Liakata, Maria et al., 'The Robot Scientist Adam' (2009) 42(8) *Computer* 46.

Kitch, Edmund W, 'Elementary and Persistent Errors in the Economic Analysis of Intellectual Property' 53(6) *Vanderbilt Law Review* (2000) 1727.

Kitch, Edmund W, 'The Nature and Function of the Patent System' (1977) 20(2) *Journal of Law and Economics* 265.

Klein, Michael A, 'The Reward and Contract Theories of Patents in a Model of Endogenous Growth' (2022) 147 *European Economic Review* 104178.

Knesch, G, 'Assessing Inventive Steps in Examination and Opposition Proceedings in the EPO' (1994) *epi (European Patent Institute) Information* 95.

Knieps, Günter, *Wettbewerbsökonomie* (Springer, Berlin and Heidelberg 2008).

Knight, Will, 'The Dark Secret at the Heart of AI', (MIT Technology Review, 11 April 2017) <https://www.technologyreview.com/s/604087/the-dark-secret-at-the-heart-of-ai/>.

Ko, Yusing, 'An Economic Analysis of Biotechnology Patent Protection' (1992) 102(3) *The Yale Law Journal* 777.

Koh Ping, Chong, 'Singapore to fast-track AI patent applications' (The Straits Times, 27 April 2019) <https://www.straitstimes.com/tech/singapore-to-fast-track-ai-patent-applications>.

Köhl, Daniel, 'Autonome KI-Programme als Erfinder im Patentrecht' (2025) *GRUR* 629.

Kohler, Josef, *Deutsches Patentrecht systematisch bearbeitet unter vergleichender Berücksichtigung des französischen Patentrechts* (J. Bensheimer, Mannheim 1878).

Kohlhepp, Peter M, 'When the Invention is an Inventor: Revitalizing Patentable Subject Matter to Exclude Unpredictable Processes' (2009) 93(2) *Minnesota Law Review* 779.

Kola, Ismail and Landis, John, 'Can the Pharmaceutical Industry Reduce Attrition Rates?' (2004) 3(8) *Nature Reviews Drug Discovery* 711.

Köllner, Malte, 'Zur Prüfung der erfinderischen Tätigkeit nach deutschem Recht' (2023) *Mitteilungen der deutschen Patentanwälte* 202.

Konertz, Roman and Schönhof, Raoul, 'Erfindungen durch Computer und künstliche Intelligenz - eine aktuelle Herausforderung für das Patentrecht' (2018) *Zeitschrift für Geistiges Eigentum* 379.

Kononenko, Igor and Kukar, Matjaž, *Machine Learning and Data Mining* (Woodhead Publishing 2007).

Kop, Mauritz, 'EU Artificial Intelligence Act: The European Approach to AI' (2021) *Stanford - Transatlantic Antitrust and IPR Developments* 1.

Koza, John R, 'Human-Competitive Results Produced by Genetic Programming' (2010) 11 *Genetic Programming and Evolvable Machines* 251.

Koza, John R / Leane, Martin A / Streeter, Matthew J / Mydlowec, William et al., *Genetic Programming IV: Routine Human-Competitive Machine Intelligence* (Kluwer Academic Publishers 2003).

Koza, John R, *Genetic Programming: On the Programming of Computers by Means of Natural Selection* (MIT Press 1992).

Krausen, Jean-Marcel, *Künstliche Intelligenz als Erfindung und als Erfinder. Patentrechtliche Auswirkungen des Fortschritts auf dem Gebiet der künstlichen Intelligenz* (Mohr Siebeck, Tübingen 2023).

Krishna, Krithika and Philip, Shiju S, 'The Path to Innovation: An Amalgamation of Patent Law and the Dynamic Competition Regime' (2015) 4(2) *Christ University Law Journal* 89.

Kronz, Hermann, 'Response in Defence of the Innovation Patent Concept' in William Kingston (ed), *Direct Protection of Innovation* (Springer, Berlin and Heidelberg 1987) 257.

Kronz, Hermann, 'Innovationspatentschutz – ein Instrument der Wirtschaftspolitik' (1983) *Mitteilungen der deutschen Patentanwälte* 128.

Kronz, Hermann, 'Patentschutz für die Innovation. Ein Modell' (1976) *Mitteilungen der deutschen Patentanwälte* 178.

Kuhnen, Rainer K, 'Securing Software Patents through the EPO' (IAM Media 2021) <https://www.iam-media.com/global-guide/innovation-invention-yearbook/2021/article/securing-software-patents-through-the-epo>.

Kulhavy, Sava, *Erfindungs- und Patentlehre: Methodik der Behandlung von Erfindungen und Patenten* (Carl Heymanns, Cologne 2009).

Kultti, Klaus / Takalo, Tuomas and Toikka, Juuso, 'Secrecy versus Patenting' (2007) 38(1) *The RAND Journal of Economics* 22.

Kumm, Alfred W, *Vom Spezialisten zum Generalisten der Technik. Ein Wegweiser zum technologischen Denken, Analysieren und Bewerten* (Haag & Herchen, Frankfurt 2003).

Kumm, Alfred W, 'Die Bewertung der erfinderischen Tätigkeit – ein rational unlösbares Jahrhundert-Problem' (1998) *epi (European Patent Institute) Information* 23.

Kummer, Max, *Das urheberrechtlich schützbare Werk* (Stämpfli, Bern 1968).

Kunczik, Niclas, 'Die Legitimation des Patentsystems im Lichte biotechnologischer Erfindungen' (2003) *GRUR* 845.

Kur, Annette / Dreier, Thomas and Luginbühl, Stefan, *European Intellectual Property Law: Text, Cases and Materials* (2nd edn, Edward Elgar 2019).

Kurzweil, Ray, 'The Coming Merging of Mind and Machine' (Scientific American, 23 March 2009) <https://www.scientificamerican.com/article/merging-of-mind-and-machine>.

Landes, William M and Posner, Richard A, *The Economic Structure of Intellectual Property Law* (Harvard University Press 2003).

Laney, Douglas, '3D data Management: controlling data volume, velocity, and variety' (Gartner, 2001) <http://blogs.gartner.com/douglaney/files/2012/01/ad949-3D-data-Management-Controlling-data-Volume-Velocity-and-Variety.pdf>.

Larenz, Karl, *Methodenlehre der Rechtswissenschaft* (6th edn, Springer, Berlin and Heidelberg 1991).

Lauber-Rönsberg, Anne and Hetmank, Sven and, 'The Concept of Authorship and Inventorship Under Pressure: Does Artificial Intelligence Shift Paradigms?' (2019) 14(7) *Journal of Intellectual Property Law & Practice* 570.

Lavagnini, Stefania, 'Commento sub artt. 64 quinquies e 64 sexies' in Luigi C Ubertazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza* (6th edn, CEDAM 2016).

Leber, Thomas M, 'The closest prior art in the problem solution approach - theoretical considerations and a dilemma' (2016) *GRUR International* 337.

Lederer, Thomas L, 'Patentierung im Bereich Künstlicher Intelligenz' (2019) *GRUR-Prax* 152.

Ledley, Fred D / Shonka McCoy, Sarah / Vaughan, Gregory et al., 'Profitability of Large Pharmaceutical Companies Compared With Other Large Public Companies' (2020) 323 *JAMA* 834.

Lee, Timothy B, 'Artificial Intelligence Is Getting More Powerful, and It's About to Be Everywhere' (Vox, 18 May 2017) <https://www.vox.com/new-money/2017/5/18/15655274/google-io-ai-everywhere>.

Leeming, John, 'Review of EPO software decisions in 2024' (J A Kemp, 5 March 2025) https://www.jakemp.com/knowledge-hub/review-of-epo-software-decisions-in-2024/?utm_source=chatgpt.com.

Lehot, Louis, 'Artificial Intelligence Comparative Guide' (Mondaq, 9 August 2024) <https://www.mondaq.com/unitedstates/technology/1059776/artificial-intelligence-comparative-guide#:~:text=Despite%20AI's%20ubiquity%20across%20every,regulate%20certain%20aspects%20of%20AI>.

Lehr, David and Ohm, Paul, 'Playing with the Data: What Legal Scholars Should Learn About Machine Learning' (2017) 51 *U.C. Davis Law Review* 653.

Leistner, Matthias, 'Injunctive Relief in the UPC – A Case for Carefully Limited Flexibility' in F Thouvenin (ed), *Kreation Innovation Märkte - Creation Innovation Markets: Festschrift für Reto M Hilty* (Springer, Berlin and Heidelberg 2023) 619.

Leistner, Matthias / Antoine, Lucie and Sagstetter, Thomas, *Big Data – Rahmenbedingungen im europäischen Datenschutz- und Immaterialgüterrecht und übergreifende Reformperspektive* (Mohr Siebeck, Tübingen 2021).

Leistner, Matthias, 'The Commission's Digital Markets and Services Package – New Rules for Big Tech and Big Data' (2021) *GRUR International* 515.

Leistner, Matthias, 'The Existing European IP Rights System and the Data Economy – An Overview With Particular Focus on Data Access and Portability' in J Drexler (ed), *Data Access, Consumer Protection and Public Welfare* (Nomos, Baden-Baden 2021) 209.

Leistner, Matthias, 'Towards an Access Paradigm in Innovation Law?' (2021) *GRUR International* 925.

Leistner, Matthias, 'Big Data and the EU Database Directive 96/9/EC: Current Law and Potential for Reform' in S Lohsse, R Schulze and D Staudenmayer (eds), *Trading Data in the Digital Economy: Legal Concepts and Tools* (Nomos, Baden-Baden 2017) 25.

Leistner, Matthias, 'Computerimplementierte Erfindungen im System des Geistigen Eigentums' in O Peifer and K Depenheuer (eds), *Geistiges Eigentum: Schutzrecht oder Ausbeutungstitel? Zustand und Entwicklungen im Zeitalter von Digitalisierung und Globalisierung* (Springer, Berlin and Heidelberg 2008) 187.

Lemley, Mark A, 'Expecting the Unexpected' (2017) 92(3) *Notre Dame Law Review* 1369.

Lemley, Mark A, 'The Surprising Virtues of Treating Trade Secrets as IP Rights' (2010) 61(2) *Stanford Law Review* 311.

Lemley, Mark A, 'Patenting Nanotechnology' (2005) 58 *Stanford Law Review* 601.

Lemley, Mark A and Burk, Dan L, 'Policy Levers in Patent Law' (2003) 89 *Virginia Law Review* 1576.

Lemley, Mark A, 'Reconceiving Patents in the Age of Venture Capital' (2000) 4 *Journal of Small & Emerging Business Law* 137.

Leviathan, Yaniv and Matias, Yossi, 'Google Duplex: An AI System for Accomplishing Real-World Tasks Over the Phone' (Google AI Blog, 8 May 2018) <https://research.google/blog/google-duplex-an-ai-system-for-accomplishing-real-world-tasks-over-the-phone/>.

Lévy, Maurice and Jouyet, Jean-Pierre, 'L'économie de l'immatériel: la croissance de demain' (Report for the French Minister of Economy, Finance and Industry, 16 March 2006) <https://www.unitary-patent.eu/content/criticisms-governance-european-patent-office.html>.

Li, Changhe / Han, Shoufei and Zeng, Sanyou, 'Basics of Evolutionary Computation Algorithms' in C Li, S Han, S Zeng and S Yang (eds), *Intelligent Optimization: Principles, Algorithms and Applications* (Springer Nature, Singapore 2024) 63.

Li, Nick and Koay, Tzeyi, 'Artificial Intelligence and Inventorship: An Australian Perspective' (2020) 15(5) *Journal of Intellectual Property Law & Practice* 399.

Libertini, Mario, 'I prodotti inventivi dell'intelligenza artificiale' (Academia, 2021) https://www.academia.edu/72692969/I_prodotti_inventivi_dellintelligenza_artificiale.

Lichtman, Douglas G and Baker, Scott, 'Strategic Disclosure in the Patent System' (Coase-Sandor Working Paper Series in Law and Economics No 107, 1-3, 2000).

Lieberman, Marvin B and Montgomery, David B, 'First-Mover Advantages' (1988) 9 *Strategic Management Journal* 41.

Lim, Daryl, 'AI & IP: Innovation & Creativity in an Age of Accelerated Change' (2018) 52 *Akron Law Review* 813.

Link, Jasmin / Dadakou, Helena and Krüger, Anne Elisabeth, 'Lowering the Risk of Bias in AI Applications' (2023) 72 *Artificial Intelligence and Social Computing* 181

Liu, Gary / Catacutan, Denise B / Rathod, Khushi / Swanson, Kyle et al., 'Deep Learning-Guided Discovery of an Antibiotic Targeting *Acinetobacter baumannii*' (2023) 19 *Nature Chemical Biology* 1342.

Liu, Yixin et al., 'Sora: A Review on Background, Technology, Limitations, and Opportunities of Large Vision Models' (2024) *arXiv* <https://arxiv.org/abs/2402.17177>.

Lobe, Adrian, 'Kreative Computer - Wenn die Software zum Erfinder wird' (Neue Zürcher Zeitung, 14 June 2016) <https://www.nzz.ch/feuilleton/kuenstliche-intelligenz-kreative-computer-wenn-die-software-zum-erfinder-wird-ld.88633>.

Locke, John, *Two Treatises of Government* (first published 1689, Peter Laslett edn, Cambridge University Press 1988).

Locke, John, *The Second Treatise on Civil Government* (Prometheus Books 1986).

Lohn, Jason D, Hornby, Gregory S and Linden, Derek S, 'Human-competitive evolved antennas' (2008) 22(3) *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 235.

Lohr, Jason D, 'Managing Patent Rights in the Age of Artificial Intelligence' (Legaltech News, 18 August 2016) <https://www.law.com/legaltechnews/almID/1202765385194/Managing-Patent-Rights-in-the-Age-of->.

Lou, Bowen and Wu, Lynn, 'Artificial Intelligence and Drug Innovation: A Large Scale Examination of the Pharmaceutical Industry' (2021) 45(3) *Management Information Systems Quarterly* 1451.

Love, Brian J, 'An Empirical Study of Patent Litigation Timing: Could a Patent Term Reduction Decimate Trolls Without Harming Innovators?' (2013) 161 *University of Pennsylvania Law Review* 1309.

Luchini, Claudio / Pea, Antonio and Scarpa, Aldo, 'Artificial Intelligence in Oncology: Current Applications and Future Perspectives' (2021) 126 *Nature* 4.

Lück, Sonja et al., 'Early Disclosure of Invention and Reduced Duplication: An Empirical Test' (2020) 66(6) *Management Science* 2677.

Luger, George F, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving* (6th edn, Pearson 2008).

Luginbuehl, Stefan, 'Patent Protection of Inventions Involving Artificial Intelligence' in N Bruun, G B Dinwoodie, M Levin and A Ohly (eds), *Transition and Coherence in Intellectual Property Law* (Cambridge University Press 2021) 191.

Luse, Kaitlin, 'The Return of the Machinery Question: Is It Different This Time?' (2017) 19 *Major Themes in Economics* 1.

Lutterbeck, Bernd / Gehring, Robert and Horns, Axel, *Sicherheit in der Informationstechnologie und Patentschutz für Software-Produkte – Ein Widerspruch?* (Berlin 2000).

Luzzatto, Ettore, *Teoria e tecnica dei brevetti d'invenzione* (Istituto Editoriale Cisalpino, Milan 1960).

Maamar, Niklas, *Computer als Schöpfer: Der Schutz von Werken und Erfindungen Künstlicher Intelligenz* (Mohr Siebeck, Tübingen 2021).

Mabey, Warren K Jr, 'Deconstructing the Patent Application Backlog... A Story of Prolonged Pendency, PCT Pandemonium & Patent Pending Pirates' (2010) 92 *Journal of the Patent and Trademark Office Society* 208.

Machlup, Fritz, 'Die wirtschaftlichen Grundlagen des Patentrechts – 1. Teil' (1961) *GRUR Ausland* 373.

Machlup, Fritz, *An Economic Review of the Patent System* (Committee Print, Washington 1958).

Machlup, Fritz and Penrose, Edith, 'The Patent Controversy in the Nineteenth Century' (1950) 10(1) *Journal of Economic History* 1.

Magazzini, Laura / Pamolli, Fabio / Riccaboni, Massimo and Rossi, Maira A, 'Patent Disclosure and R&D Competition in Pharmaceuticals' (2009) 18(5) *Economics of Innovation and New Technology* 467.

Mak, Kit-Kay and Rao Pichika, Mallikarjuna, 'Artificial Intelligence in Drug Development: Present Status and Future Prospects' (2019) 24(3) *Drug Discovery Today* 773.

Manca, Daniele and Verona, Gianmario, 'Intelligenza non solo artificiale: il potenziale di una tecnologia di cui non siamo ancora davvero consapevoli' (Corriere della Sera, 28 November 2022) https://www.corriere.it/tecnologia/22_novembre_28/intelligenza-non-solo-artificiale-il-potenziale-di-una-tecnologia-di-cui-non-siamo-ancora-davvero-consapevoli-4df0911f-e508-4aaa-9c59-3c7476c6fxlk.shtml.

Mandich, Giulio, 'Le privative industriali veneziane' (1936) *Rivista del diritto commerciale* 511.

Manyika, James et al., 'Jobs Lost, Jobs Gained: What the Future of Work Will Mean For Jobs, Skills, and Wages' (McKinsey, November 2017,) <https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages>.

Marchetti, Piergaetano and Ventrone, Marco, 'Chi fa le regole non può permettersi il lusso dell'ambiguità' (Il Sole 24 Ore, 25 April 2023).

Marcus, Gary, 'A CERN for AI and the Global Governance of AI' (Substack, 26 October 2023) <https://garymarcus.substack.com/p/a-cern-for-ai-and-the-global-governance>.

Marcus, Gary and Davis, Ernest, *Rebooting AI: Building Artificial Intelligence We Can Trust* (Pantheon 2019).

Markides, Constantinos C and Geroski, Paul A, *Fast Second: How Smart Companies Bypass Radical Innovation to Enter and Dominate Emerging Markets* (Jossey-Bass 2005).

Marr, Bernard, 'The Key Definitions of Artificial Intelligence (AI) That Explain Its Importance' (Forbes, 14 February 2018) <https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/?sh=56e9e3494f5d>.

Marshall, Elliot, 'Patent Office Faces 90-Year Backlog' (1996) 272 *Science* 643.

Martens, Bertin, 'The Impact of Data Access Regimes on Artificial Intelligence and Machine Learning' (Digital Economy Working Paper No. 2018-09, Joint Research Centre Technical Reports, 2018) <https://www.econstor.eu/bitstream/10419/202237/1/jrc-dewp201809.pdf>.

Mathely, Paul, *Le droit européen des brevets d'invention* (Journal des notaires et des avocats 1978).

Matthews, David and Greenacre, Martin, 'EU science advisers back call for a "CERN for AI" to aid research' (Science Business, 15 April 2024) <https://sciencebusiness.net/news/ai/eu-science-advisers-back-call-cern-ai-aid-research>.

Mazzi, Francesca, 'Patentability of AI Generated Drugs' (2020) 4(1) *EPLR - European Pharmaceutical Law Review* 17.

Mazzoleni, Roberto and Nelson, Richard R, 'The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate' (1998) 27(3) *Research Policy* 273.

McCarthy, John, 'What Is Artificial Intelligence?' (2007) *Stanford University* 1, <http://www-formal.stanford.edu/jmc/whatisai/node1.html>.

McCarthy, John / Minsky, Marvin L / Rochester, Nathaniel / Shannon, Claude E , 'A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence' (1955) <http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf>.

McLaughlin, Michael, 'Computer-Generated Inventions' (2019) 101 *Journal of Patent & Trademark Office Society* 224.

Medeiros, João, 'The Startup Fighting Cancer with AI' (Wired, 22 March 2016) <https://www.wired.co.uk/article/ai-cancer-drugs-berg-pharma-startup>.

Meitinger, Thomas H, 'Künstliche Intelligenz als Erfinder?' (2020) *Mitteilungen der deutschen Patentanwälte* 49.

Meitinger, Thomas H, 'Erfinderlose Erfindungen durch Know-how einer Organisation und Erfinderprinzip: kein Widerspruch' (2017) *Mitteilungen der deutschen Patentanwälte* 149.

Menell, Peter S et al., *Patent Case Management Judicial Guide* (Berkeley 2009).

Ménière, Yann and Pihlajamaa, Heli, 'Künstliche Intelligenz in der Praxis des EPA' (2019) *GRUR* 332.

Merges, Robert P and Duffy, John F, *Patent Law and Policy* (8th edn, Carolina Academic Press 2021).

Merges, Robert P, *Justifying Intellectual Property* (Harvard University Press 2011).

Merges, Robert P, 'The Trouble with Trolls: Innovation, Rent-Seeking, and Patent Law Reform' (2009) 24(4) *Berkeley Technology Law Journal* 1583.

Merges, Robert P, 'The Economic Impact of Intellectual Property Rights: An Overview and Guide' (1995) 19(2) *Journal of Cultural Economics* 103.

Merges, Robert P, 'Uncertainty and the Standard of Patentability' (1992) 7(1) *High Technology Law Journal* 1.

Metzger, Axel, 'Innovation in der Open Source Community. Herausforderungen für Theorie und Praxis des Immaterialgüterrechts' in M Eifert and W Hoffmann-Riem (eds), *Geistiges Eigentum und Innovation* (Duncker & Humbolt, Berlin 2008) 184.

Meurer, Michael J, 'Business Method Patents and Patent Floods' (2002) 8 *Washington University Journal of Law & Policy* 309.

Miglierini, Giuliana, 'Verso il superamento del concetto di ovvietà in campo brevettuale?' (Fatti & Persone, 1 April 2019) <https://www.notiziariochimicofarmaceutico.it/2019/04/03/verso-il-superamento-del-concetto-di-ovvietà-in-campo-brevettuale/>.

Mill, John S, *Principles of Political Economy* (London 1870).

Minsky, Marvin L, *Computation: Finite and Infinite Machines* (Prentice-Hall 1967).

Minssen, Timo, 'Meanwhile on the Other Side of the Pond: Why Biopharmaceutical Inventions That Were Obvious to Try Still Might Be Non-Obvious - Part I' (2010) 9(1) *Chicago-Kent Journal of Intellectual Property* 60.

Mohammed, Emir A C, 'The Utilitarian Fruits Approach to Justifying Patentable Subject Matter' (2011) 10 *John Marshall Review of Intellectual Property Law* 753.

Mohammed, Emir A C, 'What is an Invention? A Review of the Literature on Patentable Subject Matter' (2008) 15(2) *Richmond Journal of Law and Technology* 1.

Moir, Hazel V J, 'An inventive step for the patent system?' (2013) 35(3) *European Intellectual property Review* 125.

Moraru, Felicia and Cretu, Nick, 'Interview with Gerd Gigerenzer on the Future of AI' (Founders Project, 26 January 2024) <https://www.foundersproject.io/p/gerd-gigerenzer-ai>.

Morone, Giovanni / De Angelis, Luigi / Cinnera, Alex Martino, / Carbonetti, Riccardo et al., 'Artificial Intelligence in Clinical Medicine: A State-of-the-Art Overview of Systematic Reviews with Methodological Recommendations for Improved Reporting' (2025) 7 *Frontiers in Digital Health* <https://doi.org/10.3389/fdgth.2025.1550731>, 2 et seq.

Mossoff, Adam, 'Patent Term Extensions Will Help Speed up Development of Coronavirus Drugs' (Hudson Institute, 12 March 2020) <https://www.hudson.org/research/15811-patent-term-extensions-will-help-speed-up-development-of-coronavirus-drugs>.

Moufang, Rainer, 'A Critical Mind' in C Godt and M Lamping (eds), *A Critical Mind* (Springer, Berlin and Heidelberg 2023) 474.

Müller, Martin, 'Issues in Patenting Artificial Intelligence from an EPO Perspective' (2024) 19(3) *Journal of Intellectual Property Law & Practice* 8.

Muselli, Marco, ‘Approximation Properties of Positive Boolean Functions’ in B Apolloni et al. (eds), *Neural Nets. Lecture Notes in Computer Science* (Springer, Berlin and Heidelberg 2006) 18.

Muselli, Marco and Liberati, Diego, ‘Training Digital Circuits with Hamming Clustering’ in 47(4) *IEEE Transactions on Circuits and Systems - I: Fundamental Theory and Applications* (2000) 513.

Musso, Alberto ‘Ditta e insegna, marchio, brevetti, disegni e modelli, concorrenza’ in G De Nova (ed), *Commentario del codice civile e codici collegati Scialoja-Branca-Galgano* (UTET, Bologna 2012).

Nack, Ralph, ‘The “Technical Invention” Criterion’ in M Haedicke and H Timmann (eds), *Patent Law: A Handbook on European and German Patent Law* (Beck, Munich 2014) 65.

Nadejda Alkhalidi, ‘What Is AI Bias Really, and How Can You Combat It?’ (ITRex, 27 August 2024) <https://itrexgroup.com/blog/ai-bias-definition-types-examples-debiasing-strategies/>.

Nafizah, Uly Y / Roper, Stephen and Mole, Kevin, ‘Estimating the innovation benefits of first-mover and second-mover strategies when micro-businesses adopt artificial intelligence and machine learning’ (2023) 62 *Small Business Economics* 411.

Nägerl, Joel, ‘Abgrenzung vom Stand der Technik – Neuheit und erfinderische Tätigkeit’, in M Haedicke and H Timmann (eds), *Handbuch des Patentrechts* (2nd edn, Beck, Munich 2020).

Nägerl, Joel / Neuburger, Benedikt and Steinbach, Frank, ‘Künstliche Intelligenz: Paradigmenwechsel im Patentsystem’ (2019) *GRUR* 336.

Nakayama, Ichiro, ‘Patentability and PHOSITA in the AI Era (with a focus on inventive step)’ (WIPO Conversation on IP and Frontier Technologies, 21 September 2022) https://www.wipo.int/edocs/mdocs/mdocs/en/wipo_ip_conv_ge_2_22/wipo_ip_conv_ge_2_22_p3_3.pdf.

Nakayama, Ichiro, ‘Patentability and PHOSITA in the AI Era – A Japanese Perspective’ in R Lee, P Hilty and L Liu (eds), *Artificial Intelligence & Intellectual Property* (Oxford University Press 2021) 99.

NASA, ‘Intelligent Agents: A Technology and Business Applications Analysis’ (NASA Technical Reports Server 2006) <https://ntrs.nasa.gov/citations/20060024675>.

National Security Commission on Artificial Intelligence, *Final Report* (March 2021) <https://www.nscai.gov/wp-content/uploads/2021/03/Full-Report-Digital-1.pdf>.

Nelson, Richard D and Mazzoleni, Roberto, ‘Economic Theories About the Cost and Benefits of Patents’ in National Research Council (US), *Intellectual Property Rights and the Dissemination of Research Tools in Molecular Biology* (National Academies Press 1997), <https://www.ncbi.nlm.nih.gov/books/NBK233535/>.

Nigam, Varun, *Understanding Neural Networks: From Neuron to RNN, CNN, and Deep Learning* (Towards Data Science, 11 September 2018) <https://towardsdatascience.com/understanding-neural-networks-from-neuron-to-rnn-cnn-and-deep-learning-cd88e90e0a9>.

Nosengo, Nicola, ‘Can Artificial Intelligence Create the Next Wonder Material?’ (2016) 533 *Nature* 22.

Noto La Diega, Guido / Cifrodelli, Gabriele and Dermawan, Artha, ‘Sustainable Patent Governance of Artificial Intelligence: Recalibrating the European Patent System to Foster Innovation (SDG 9)’ in B Amani, C Ncube and M Rimmer (eds), *Elgar Companion on Intellectual Property and Sustainable Development Goals* (Edward Elgar 2023) 299.

Noto La Diega, Guido, ‘Associate Professor Guido Noto La Diega’s Comments on WIPO’s “Draft Issues Paper on Intellectual Property and Artificial Intelligence” (WIPO/IP/AI/2/GE/20/1)’ (2019).

O’Sullivan, Liz, ‘How the law got it wrong with Apple Card’ (TechCrunch, 14 August 2021) <https://techcrunch.com/2021/08/14/how-the-law-got-it-wrong-with-apple-card/>.

Ogburn, William F and Thomas, Dorothy, ‘Are Inventions Inevitable? A Note on Social Evolution’ (1922) 37(1) *Political Science Quarterly* 83.

Ohly, Ansgar, ‘Zuweisung von Daten: immaterialgüterrechtliche Lösungen’ in Franz Hofmann, Boris Raue and Herbert Zech (eds), *Eigentum in der digitalen Gesellschaft* (Mohr Siebeck, Tübingen 2022) 135.

Ohly, Ansgar, ‘Wie weit reicht der Patentschutz an Universitäten?’ (Forschung & Lehre, 31 January 2022) <https://www.forschung-und-lehre.de/recht/wie-weit-reicht-der-patentschutz-an-universitaeten-4389>.

Ohly, Ansgar, ‘Introduction: The Quest for Common Principles of European Intellectual Property Law – Useful, Futile, Dangerous?’ in A Ohly (ed), *Common Principles of European Intellectual Property Law* (Mohr Siebeck, Tübingen 2012) 3.

Ohly, Ansgar, ‘“Patenttrolle” oder: Der patentrechtliche Unterlassungsanspruch unter Verhältnismäßigkeitsvorbehalt? – Aktuelle Entwicklungen im US-Patentrecht und ihre Bedeutung für das deutsche und europäische Patentsystem’ (2008) *GRUR International* 787.

Ohly, Ansgar, ‘Reverse Engineering: Unfair Competition or Catalyst for Innovation?’ in W Prinz zu Waldeck und Pyrmont, M Adelman, R Brauneis, J Drexler, and R Nack (eds), *Patents and Technological Progress in a Globalized World: Liber Amicorum Joseph Straus* (Springer, Berlin and Heidelberg 2008) 535.

Ohly, Ansgar, ‘Software und Geschäftsmethoden im Patentrecht’ (2001) *Computer und Recht* 809.

Osha, Jonathan P, *Artificial Intelligence and Patents: An International Perspective on Patenting AI-Related Inventions* (AIPPI Law Series Vol 8, Wolters Kluwer 2023).

Osterloh, Margit and Luethi, Roger, 'Commons without Tragedy: Das Beispiel Open Source Software' in M Eifert and W Hoffmann-Riem (eds), *Geistiges Eigentum und Innovation* (Duncker & Humblot, Berlin 2008) 145.

Ottolia, Andrea, 'Introduzione agli artt. 45-81 d.lgs. 10 febbraio 2005, n. 30', in L C Ubertazzi (ed), *Commentario breve alle leggi su proprietà intellettuale e concorrenza*, (7th edn Wolters Kluwer, Milan 2019).

Ottolia, Andrea, *Big Data e innovazione computazionale* (Giappichelli, Turin 2017).

Pagenberg, Jochen, 'Article 56' in F K Beier, K Haertel and G Schricker (eds), *Münchener Gemeinschaftskommentar, EPÜ* (Carl Heymanns, Cologne 1984).

Pagenberg, Jochen, 'The Concept of the "Inventive Step" in the European Patent Convention' (1974) *IIC - International Review of Intellectual Property and Competition Law* 157.

Pairolero, Nicholas A / Toole, Andrew A / Pappas, Peter-Anthony / de Grazia, Charles A W et al., 'Closing the Gender Gap in Patenting: Evidence from a Randomized Control Trial at the USPTO' (2025) 17(3) *American Economic Journal: Economic Policy* 281.

Papastefanou, Stefan, 'KI-gestützte Schöpfungsprozesse im geistigen Eigentum' (2020) *Wettbewerb in Recht und Praxis* 290.

Parchomovsky, Gideon and Wagner, R Polk, 'Patent Portfolios' (2005) 154(1) *University of Pennsylvania Law Review* 49.

Park, Alice, 'Microsoft's AI Is Better Than Doctors at Diagnosing Disease' (Time, 2 July 2025) <https://time.com/7299314/microsoft-ai-better-than-doctors-diagnosis/>.

Pathak, Rajesh K / Singh, Dev B / Sagar, Mamta / Maunthiyal, Mamta et al., 'Computational Approaches in Drug Discovery and Design' in Dev Bukhsh Singh (ed), *Computer-Aided Drug Design* (Springer, Berlin and Heidelberg 2020) 1.

Paul, Debleena / Sanap, Gaurav / Shenoy, Snehal / Kalyane Dnyaneshwar et al., 'Artificial Intelligence in Drug Discovery and Development' (2021) 26(1) *Drug Discovery Today* 80.

Paulini, Oskar, 'Die KI-generierte Erfindung: die patentrechtliche Zuordnung technischer Leistungen im Zeitalter künstlicher Intelligenz' (PhD thesis, LMU Munich 2023) <https://edoc.ub.uni-muenchen.de/32033/>.

Pesch, Benjamin and Augenstein, Kather, 'Unzureichende Erfinderbenennung bei Angabe künstlicher Intelligenz' (2020) *GRUR-Prax* 84.

Pessers, Lodewijk, *The Inventiveness Requirement in Patent Law: An Exploration of Its Foundations and Functioning* (1st edn, Kluwer Law International 2016).

Pfanner, Klaus, ‘Vereinheitlichung des materiellen Patentrechts im Rahmen des Europarats’ (1962) *GRUR Ausland* 545.

Picht, Peter G and Thouvenin, Florent, ‘AI and IP: Theory to Policy and Back Again – Policy and Research Recommendations at the Intersection of Artificial Intelligence and Intellectual Property’ (2023) *IIC - International Review of Intellectual Property and Competition Law* 916.

Picht, Peter G / Brunner, Valerie and Schmid, Rena, ‘Artificial Intelligence and Intellectual Property Law: From Diagnosis to Action’ (Max Planck Institute for Innovation & Competition Research Paper No. 22-08, 28 May 2022) <https://ssrn.com/abstract=4122985>.

Pieper, Carl, *Der Erfinderschutz und die Reform der Patentgesetze: Amtlicher Bericht über den Internationalen Patent-Congress zur Erörterung der Frage des Patentschutzes* (Dresden 1873).

Pila, Justine, ‘The Future of the Requirement for an Invention: Inherent Patentability as a Pre- and Post-Patent Determinant’ in E Arezzo and G Ghidini (eds), *Biotechnology and Software Patent Law: A Comparative Review of New Developments* (Edward Elgar 2011).

Pila, Justine, *The Requirement for an Invention in Patent Law* (Oxford University Press, Oxford 2010).

Pilger, Jens, ‘The UPC’s Approach to Assess Inventive Step – A New Approach Reflecting the German Practice?’ (JUVE Patent, 27 January 2025) <https://www.juve-patent.com/news-and-stories/legal-commentary/the-upcs-approach-to-assess-inventive-step-a-new-approach-reflecting-the-german-practice>.

Plotkin, Robert, ‘Commentary: How AI is Affecting the Patent System’ (Reuters, 28 June 2023) <https://www.reuters.com/legal/litigation/how-ai-is-affecting-patent-system-2023-06-28/>.

Plotkin, Robert, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business* (Stanford University Press 2009).

Poole, David L and Mackworth, Alan K, *Artificial Intelligence: Foundations of Computational Agents* (Cambridge University Press 2010).

Poole, David / Mackworth, Alan K and Goebel, Randy, *Computational Intelligence: A Logical Approach* (Oxford University Press 1998).

Portal, Jean-François ‘Contribution à une Nouvelle Analyse de l’Approche Problème-Solution’ (1995) 2 *epi (European Patent Institute) Information* 69.

Pouliquen, Bruno, ‘Advanced Technology Applications Center: Strategy for Developing AI Projects, List of Current AI Projects’ (WIPO Meeting on ICT Applications and Artificial Intelligence for Intellectual Property Administration, May 2018) https://www.wipo.int/edocs/mdocs/globalinfra/en/wipo_ip_itai_ge_18/wipo_ip_itai_ge_18_p16.pdf.

Properzi, Francesca / Taylor, Karen/ Steedman, Mark and Ronte /Hanno, 'Intelligent drug discovery, Powered by AI' (Deloitte Insights, 2019) www2.deloitte.com/us/en/insights/industry/life-sciences/artificial-intelligence-biopharma-intelligent-drug-discovery.html.

Publications Office of the European Union, 'The Role of Artificial Intelligence in Processing and Generating New Data' (data.europa.eu, 11 July 2024) <https://data.europa.eu/en/publications/reports/role-artificial-intelligence-processing-and-generating-new-data>.

Quinn, Gene, 'What "The Economist" Doesn't Get About Patents' (IP Watch Dog, 13 August 2015) <https://ipwatchdog.com/2015/08/13/what-the-economist-doesnt-get-about-patents/id=60626/>.

Rahmatian, Andreas, 'A Fundamental Critique of the Law-and-Economics Analysis of Intellectual Property Rights' (2013) 17 *Marquette Intellectual Property Law Review* 191.

Ramalho, Ana, *Intellectual Property Protection for AI-generated Creations: Europe, United States, Australia and Japan* (Routledge 2021).

Ramalho, Ana, 'Patentability of AI-generated inventions: is a reform of the patent system needed?' (2018) *Institute of Intellectual Property, Foundation for Intellectual Property of Japan* 1.

Ramalho, Ana, 'Will robots rule the (artistic) world? A proposed model for the legal status of creations by artificial intelligence systems' (2017) 21(1) *Journal of Internet Law* 12.

Ramello, Giovanni B, 'Private Appropriability and Sharing of Knowledge: Convergence or Contradiction? The Opposite Tragedy of the Creative Commons' in Lynn Takeyama et al. (eds), *Developments in the Economics of Copyright. Research and Analysis* (Edward Elgar 2005) 134.

Rashid, Tariq, *Neuronale Netze selbst programmieren: ein verständlicher Einstieg mit Python* (O'Reilly 2017).

Rau, Karl H, *Lehrbuch der politischen Ökonomie* (Heidelberg 1839).

Reale, Roberto / Biasin, Elisabetta / Scardovi, Alessandro and Toro, Stefano, 'The Design and Implementation of a National AI Platform for Public Healthcare in Italy: Implications for Semantics and Interoperability' (2023) *arXiv* <https://doi.org/10.48550/arXiv.2304.11893>.

Rektorschek, Phillip and Baus, Tobias, 'Protectability and Enforceability of AI-Generated Inventions' in K Jacob, D Schindler and R Strathausen (eds), *Liquid Legal, Towards a Common Legal Platform* (Springer, Berlin and Heidelberg 2020) 459.

Rich, Giles S, 'Laying the Ghost of the "Invention" Requirement' (1972) 1 *APLA Quarterly Journal* 26.

Richardson, Julie, 'Quality and Service at the EPO' (Reddie & Grose, 11 July 2017) <https://www.reddie.co.uk/2017/07/11/quality-service-epo/>.

Richardson, Peter / Griffina, Ivan / Tuckera, Catherine and Smith, Dan et al., 'Baricitinib as Potential Treatment for 2019-nCoV Acute Respiratory Disease' (2020) 395(10223) *The Lancet* e30.

Rigg, Oliver /Williams, Lisa and Robin, Gemma, 'Patenting AI at the EPO and USPTO' (HLK, 7 May 2024) <https://www.hlk-ip.com/patenting-ai-at-the-epo-and-uspto/>.

Rimmer, Matthew, 'The Artificial Inventor and the Future of Patent Law' (2021) *IIC - International Review of Intellectual Property and Competition Law* 1.

Robitzski, Dan, 'Scientists Are Trying to List AI as the Inventor on a New Patent' (Futurism, 2 August 2019) <https://futurism.com/scientists-ai-inventor-patent>.

Roin, Benjamin N, 'The Case for Tailoring Patent Awards Based on Time-to-Market' (2014) 61(3) *UCLA Law Review* 672.

Rosenblatt, Frank, *The Perceptron: A Theory of Statistical Separability in Cognitive Systems* (Project Para) (Cornell Aeronautical Laboratory 1958).

Rotman, David, 'Reinvent How We Invent' (MIT Technology Review, 15 February 2019) www.technologyreview.com/2019/02/15/137023/ai-is-reinventing-the-way-we-invent/.

Ruse-Khan, Henning G and Romandini, Roberto, 'Patentability of Pharmaceutical Inventions Under TRIPS: Domestic Court Practice as a Test for International Policy Space' (2016) *Max Planck Institute for Innovation & Competition Research Paper No 16-02* <https://ssrn.com/abstract=2736224>.

Russell, Stuart J and Norvig, Peter, *Artificial Intelligence: A Modern Approach* (3rd edn, Pearson 2010).

Rüthers, Bernd / Fischer, Christian and Birk, Axel, *Rechtstheorie: mit juristischer Methodenlehre* (Beck, Munich 2018).

Rutkin, Aviva, 'Computer Generates All Possible Ideas to Beat Patent Trolls' (New Scientist, 18 April 2016) <https://www.newscientist.com/article/2084755-computer-generates-all-possible-ideas-to-beat-patent-trolls/>.

Sabellek, Sven, *Patente auf nanotechnologische Erfindungen* (Carl Heymanns, Cologne 2014).

Salsberg, Corey, 'Novartis Comments on Artificial Intelligence and Inventorship (Docket PTO-P-2022-0045, 88 FR 9492)' (Novartis, 15 May 2023).

Salvatore, Vincenzo and Chammah, Vivian G, 'Advancing Clinical Trials through Artificial Intelligence: A Legal Perspective' (2020) 12(6) *Journal of Clinical Studies* 44.

Samek, Wojciech and Müller, Klaus-Robert, 'Towards Explainable Artificial Intelligence' in W Samek et al. (eds), *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning* (Springer, Berlin and Heidelberg 2019) 5.

Samore, William, 'Artificial Intelligence and the Patent System: Can a New Tool Render a Once Patentable Idea Obvious?' in W Barfield and U Pagallo (eds), *Research Handbook of Law and Artificial Intelligence* (Edward Elgar 2018) 471.

Samuelson, Pamela, 'Benson Revisited: The Case Against Patent Protection for Algorithms and Other Computer Program-Related Inventions' (1990) 39 *Emory LJ* 1025.

Sanseverino, Giuseppe, 'Ex machina. La novità e l'originalità dell'invenzione "prodotta" dall'IA' (2018) *AIDA - Annali Italiani del Diritto D'autore, della Cultura e dello Spettacolo* 3.

Sanseverino, Giuseppe, 'The Ability to Chase Down Our Dreams. Inventive Step and Artificial Intelligence' (2018) *I Battelli del Reno* 9, <https://ssrn.com/abstract=3401421>.

Savage, Neil, 'Drug discovery companies are customizing ChatGPT: here's how' (2023) 41 *Nature Biotechnology* 585.

Schäfer, Hans-Bernd and Ott, Claus, *Lehrbuch der ökonomischen Analyse des Zivilrechts* (4th edn, Springer, Berlin and Heidelberg 2012).

Schellekens, Maurice, 'Artificial Intelligence and the re-imagination of inventive step' (2022) 13(2) *Journal of Intellectual Property, Information Technology and E-Commerce Law* 89, <https://www.jipitec.eu/archive/issues/jipitec-13-2-2022/5537>.

Schiff, Gordon D, 'AI-Driven Clinical Documentation - Driving Out the Chitchat?' (2025) 392(19) *New England Journal of Medicine* 1877.

Schippel, Helmut, *La storia delle privative industriali nella Venezia del '400* (Centro tedesco di studi veneziani, Venezia 1989).

Schmid, Michael, 'Revolutionizing Patent Examination: Will AI-PreSearch Transform the EPO's Approach?' (RichardT, 7 August 2024) <https://www.richardt.eu/en/news/detail/revolutionizing-patent-examination/>.

Schneider, Gisbert, 'Mind and Machine in Drug Design' (2019) 1 *Nature Machine Intelligence* 128.

Schneider, Giulia and Abriani, Niccolò, *Diritto delle imprese e intelligenza artificiale - Dalla Fintech alla Corptech* (Il Mulino, Bologna 2021).

Schneider, Ingrid, 'Governing the patent system in Europe: the EPO's supranational autonomy and its need for a regulatory perspective' (2009) 36(8) *Science and Public Policy* 619.

Schork, Nicholas J, 'Artificial Intelligence and Personalized Medicine' (2019) 178 *Cancer Treatment and Research* 265.

Schrön, Viktoria, *Künstliche Intelligenz im Patentrecht: Der Erfinderbegriff als Steuerungsinstrument für die Schutzfähigkeit von Erfindungen unter Verwendung künstlicher Intelligenz* (Nomos, Baden-Baden 2023).

Schulte, Eva, 'Patentability of AI-Generated Inventions: Legal Challenges and Reform Proposals' (2023) *IIC - International Review of Intellectual Property and Competition Law* 521.

Schulte, Rainer / Rainer, Moufang, *Patentgesetz mit Europäischem Patentübereinkommen* (11th edn, Carl Heymanns, Cologne 2022).

Schweitzer, Heike and Metzger, Axel, 'Data Access under the Draft Data Act, Competition Law and the DMA: Opening the Data Treasures for Competition and Innovation?' (2023) *GRUR International* 337.

Schweitzer, Heike / Metzger, Alex / Blind, Knut / Richter Heiko et al., 'Data Access and Sharing in Germany and in the EU: Towards a Coherent Legal Framework for the Emerging Data Economy: A Legal, Economic and Competition Policy Angle - Final Report (Expertenstudie im Auftrag des Bundesministeriums für Wirtschaft und Klimaschutz)' (2022).

Scotchmer, Suzanne, *Innovation and Incentives* (MIT Press 2004).

Searle, John R, 'Minds, Brains and Programs' 3(3) *The Behavioral and Brain Sciences* 417.

Sellnick, Hans-Joachim, 'Erfindung, Entdeckung und die Auseinandersetzung um die Umsetzung der Biopatentrichtlinie der EU' (2002) *GRUR* 121.

Sellwood, Matthew A et al., 'Artificial Intelligence in Drug Discovery' (2018) 10(17) *Future Medicinal Chemistry* 2025.

Sena, Giuseppe, 'I diritti sulle invenzioni e sui modelli industriali', in A Cicu et al., *Trattato di diritto civile e commerciale* (4th edn, Giuffrè, Milan 2011).

Senftleben, Martin and Buijelaar, Laurens, 'Robot Creativity: An Incentive-Based Neighbouring Rights Approach' (2020) 42(12) *European Intellectual Property Review* 797.

Seville, Catherine, *EU Intellectual Property Law and Policy* (2nd edn, Edward Elgar 2018).

Shapiro, Carl, 'Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting' in Adam B Jaffe, Josh Lerner and Scott Stern (eds), *Innovation Policy and the Economy I* (MIT Press 2001) 119.

Sharma, Yogita, 'Patentability of AI Inventions' (iPleaders, 29 January 2023) <https://blog.iplayers.in/patentability-of-ai-inventions/>.

Shemtov, Noam and Gabison, Garry, 'The Inventive Step Requirement and the Rise of the AI Machines' in R Abbott (ed), *Research Handbook on Intellectual Property and Artificial Intelligence* (Edward Elgar 2022) 423.

Shemtov, Noam and Gabison, Garry, 'The Inventive Step Requirement and the Rise of the AI Machines' (2022) *Queen Mary Law Research Paper* No. 375/2022 7.

Shemtov, Noam, 'A Study on Inventorship in Inventions Involving AI Activity' (Commissioned by the EPO, February 2019) [http://documents.epo.org/projects/babylon/eponet.nsf/0/3918F57B010A3540C125841900280653/\\$File/Concept_of_Inventorship_in_Inventions_involving_AI_Activity_en.pdf](http://documents.epo.org/projects/babylon/eponet.nsf/0/3918F57B010A3540C125841900280653/$File/Concept_of_Inventorship_in_Inventions_involving_AI_Activity_en.pdf).

Sherman, Brad, 'Regulating Access and Use of Genetic Resources: Intellectual Property Law and Biodiscovery' (2003) 25(7) *European Intellectual Property Review* 301.

Sherman, Brad and Bently, Lionel, *The Making of Modern Intellectual Property Law* (Cambridge University Press 1999).

Shimizu, Yugo / Ohta, Masateru / Ishida, Shoichi / Terayama, Kei et al., 'AI-driven Molecular Generation of Not-patented Pharmaceutical Compounds Using World Open Patent Data' (2023) 15 *Journal of Cheminformatics* 120 <https://jcheminf.biomedcentral.com/articles/10.1186/s13321-023-00791-z#citeas>.

Shorten, Connor, 'Unsupervised Feature Learning' (Towards Data Science, 2 February 2021) <https://towardsdatascience.com/unsupervised-feature-learning-46a2fe399929>.

Shrestha, Sannu K, 'Trolls or Market-Makers? An Empirical Analysis of Nonpracticing Entities' (2010) 110 *Columbia Law Review* 114.

Sichelmann, Ted and Graham, Stuart J H, 'Patenting by Entrepreneurs: An Empirical Study' (2010) 17 *Michigan Telecommunications and Technology Law Review* 111.

Sichelmann, Ted, 'Commercializing Patents' (2010) 62(2) *Stanford Law Review* 341.

Sideri, Massimo, 'Il robot che poteva ingannarci tutti' (Corriere della Sera, 16 February 2019) 15.

Siemens, Werner (ed), *Positive Vorschläge zu einem Patent-Gesetz: Denkschrift der Ältesten der Kaufmannschaft zu Berlin* (Bittkow, Berlin 1869).

Signorelli, Andrea D, 'I tre livelli dell'intelligenza artificiale' (Andrea Daniele Signorelli, 5 November 2019) <https://andreadanielesignorelli.com/2019/11/05/tre-livelli-intelligenza-artificiale-ani-agi/>.

Silver, David et al., 'A General Reinforcement Learning Algorithm Masters Chess, Shogi and Go Through Self-Play' (2019) 362 *Science* 1140.

Simon, Brenda M, 'The Implications of Technological Advancement for Obviousness' (2013) 19 *Michigan Telecommunications and Technology Law Review* 331.

Simon, Herbert A, 'Artificial Intelligence: An Empirical Science' (1995) 77(1) *Artificial Intelligence* 95.

Simonite, Tom, 'Software Dreams Up New Molecules in Quest for Wonder Drugs' (MIT Technology Review, 3 November 2016) <https://www.technologyreview.com/s/602756/software-dreams-up-new-molecules-in-quest-for-wonder-drugs/>.

Singer, Margarete and Stauder, Dieter (eds), *The European Patent Convention* (Vol I, Sweet & Maxwell, London 2003).

Sipser, Michael, *Introduction to the Theory of Computation* (Course Technology 2006).

Sirilli, Giorgio, 'Patents and Inventors: An Empirical Study' (1987) 16(2) *Research Policy* 157.

Sloss, Andrew N and Gustafson, Steven, 'Evolutionary Algorithms Review' (2019) *arXiv* <https://doi.org/10.48550/arXiv.1906.08870>.

Slowinski, Peter R, 'Artificial Intelligence, Novelty and Inventive Step: What Is the Impact of AI on Patent Law?' in Z Sikorski and J Zemła-Pacud (eds), *Patents as an Incentive for Innovation* (Wolters Kluwer, Alphen aan den Rijn 2021) 256.

Smalec, Agnieszka, 'Big Data as a Tool Helpful in Communication Management' (2021) 192 *Procedia Computer Science* 5156.

Small, Gary / Husband, Ben and Johnson, Laura, 'Patenting AI: Three Reasons Why Patent Applications for Applied AI Inventions Do Not Succeed at the EPO' (Carpmaels & Ransford, 5 April 2023) <https://www.carpmaels.com/patenting-ai-three-reasons-why-patent-applications-for-applied-ai-inventions-do-not-succeed-at-the-epo/>.

Smith, Adam, *Wealth of Nations*, W Strahan and T Cadell (eds.) (London 1776).

Soans, Cyril, 'Some Absurd Presumptions in Patent Cases' (1966) 10 *Patent, Trademark and Copyright Journal of Research and Education* 433.

Somaya, Deepak and Varshney, Lav R, 'Ownership Dilemmas in an Age of Creative Machines' (2020) 36(2) *Winter Issues in Science & Technology* 79.

Somaya, Deepak and Varshney, Lav R, 'Embodiment, Anthropomorphism, and Intellectual Property Rights for AI Creations' in J Furman, G Marchant et al (eds) *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society* (AIE'S 2018) 278.

Sordelli, Luigi, 'Il paradigma della "persona esperta del ramo" nella legge sulle invenzioni' in *Studi in onore di Remo Franceschelli* (Giuffrè 1983).

Sperry, Christina, 'Artificial Intelligence (AI) Takes a Role in USPTO Patent Searches' (Mintz, 8 November 2022) <https://www.mintz.com/insights-center/viewpoints/2231/2022-11-08-artificial-intelligence-ai-takes-role-uspto-patent>.

Spulber, Daniel F, 'How Patents Provide the Foundation of the Market for Inventions' (2014) 11(2) *Journal of Competition Law & Economics* 271.

Stanková, Eva, 'Human Inventorship in European Patent Law' (2021) 80(2) *The Cambridge Law Journal* 2.

Sterckx, Sigrid and Cockbain, Julian, *Exclusions from Patentability: How Far Has the European Patent Office Eroded Boundaries* (Cambridge University Press 2012).

Stergiou, Christos and Siganos, Dimitrios, 'Artificial Neural Network in Medicine' (2014) <http://www-students.doc.ic.ac.uk/~cbp/article2.htm>.

Stierle, Martin and Valtere, Laura, 'Addressing the Gene Therapy Bottleneck in the EU: Patent vs Regulatory Incentives' (2025) *GRUR International* 399.

Stierle, Martin, 'A *De Lege Ferenda* Perspective on Artificial Intelligence Systems Designated as Inventors in the European Patent System' (2021) *GRUR International* 115.

Stierle, Martin, 'Artificial Intelligence Designated as Inventor – An Analysis of the Recent EPO Case Law' (2020) *GRUR International* 918.

Stierle, Martin, *Das nicht-praktizierte Patent* (Mohr Siebeck, Tübingen 2018).

Stokel-Walker, Chris, 'Twitter's \$ 42000-per-Month API Prices Out Nearly Everyone' (Wired, 10 March 2023) <https://www.wired.com/story/twitter-data-api-prices-out-nearly-everyone/>.

Stokes, Jonathan M / Yang, Jevin / Swanson, Kyle / Jin, Wengong et al., 'A Deep Learning Approach to Antibiotic Discovery' (2020) 180(4) *Cell* 688 <https://www.cell.com/cell/pdf/S0092-8674%2820%2930102-1.pdf>.

Stone, Peter / Brooks, Rodney / Brynjolfsson, Erik and Calo / Ryan et al., *Artificial Intelligence and Life in 2030: One Hundred Year Study on Artificial Intelligence | Report of the 2015 Study Panel* (Stanford University 2016) <https://ai100.stanford.edu/2016-report>.

Straus, Joseph, 'Some Lessons from "DABUS" Patent Applications' in C Concetto, A Mirone, R Pennisi et al. (eds), *Studi di diritto commerciale in onore di Vincenzo di Cataldo* (Giappichelli, Turin 2021) 624.

Straus, Joseph, 'Will Artificial Intelligence Change Some Patent Law Paradigms?' (2021) *Zbornik znanstvenih razprav / Univerza v Ljubljani, Pravna Fakulteta* (Collection of Scientific Papers / University of Ljubljana, Faculty of Law) 11.

Straus, Joseph, 'Biotechnologische Erfindungen - ihr Schutz und seine Grenzen' (1992) *GRUR* 252.

Straus, Joseph and Moufang, Rainer, *Hinterlegung und Freigabe von biologischem Material für Patentierungszwecke: Patent und eigentumsrechtliche Aspekte* (Nomos, Baden-Baden 1989).

Summerfield, Mark, ‘The Impact of Machine Learning on Patent Law, Part 2: Machine-Assisted Inventing’ (Patentology, 21 January 2018) https://blog.patentology.com.au/2018/01/the-impact-of-machine-learning-on_21.html.

Suominen, Kaisa / de Lange, Peter / Rudge, Andrew J / (ed), *Visser’s Annotated European Patent Convention* (Wolters Kluwer, Alphen aan den Rijn 2022).

Suominen, Kaisa / Kiviniemi, Teemu / Laine, Jukka, *Drafting Patents for Europe* (2nd edn, CIPA 2021).

Sven J Körner, ‘Nachvollziehbarkeit von KI-basierten Entscheidungen’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Beck, Munich 2020) 15.

Szabo, George S A, ‘The Problem and Solution Approach in the European Patent Office’ (1995) *IIC - International Review of Intellectual Property and Competition Law* 457.

Taddy, Matt, ‘The Technological Elements of Artificial Intelligence’ (NBER Working Paper No. 24301, 2018) <https://www.nber.org/papers/w24301.pdf>.

Tafari, Giovanni et al., ‘Disclosure of Grounds of European Withdrawn and Refused Applications: A Step Forward on Regulatory Transparency’ (2013) 75(4) *British Journal of Clinical Pharmacology* 1149.

Tardi, Carla, ‘What Is Moore's Law and Is It Still True?’ (Investopedia, 2 April 2024) <https://www.investopedia.com/terms/m/mooreslaw.asp>.

Team Gemini and Google / David, Oana et al., ‘Gemini: A Family of Highly Capable Multimodal Models’ (2025) *arXiv* <https://arxiv.org/abs/2312.11805> 1 et seq.

Thomas, Daniel X, ‘T 1193/23 - A chatbot does not replace the skilled person’ (IPappify Blog, 19 May 2025) <https://blog.ipappify.de/63310-2/>.

Thomsen, Peter R et al., ‘AI in Biopharma Research: A Time to Focus and Scale’ (McKinsey, 10 October 2022) 2 <https://www.mckinsey.com/industries/life-sciences/our-insights/ai-in-biopharma-research-a-time-to-focus-and-scale>.

Tilman, Winfried, ‘Introduction to this Commentary’ in W Tilman and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (Oxford University Press 2018) 19.

Tilman, Winfried, ‘Articles 20 and 21 UPCA’ in W Tilman and C Plassmann (eds), *Unified Patent Protection in Europe: A Commentary* (Oxford University Press 2018) 440.

Tocchetti, Andrea and Brambilla, Marco, ‘The Role of Human Knowledge in Explainable AI’ (2022) 7(7) *Data* <https://doi.org/10.3390/data7070093> 93.

Tochtermann, Lea, ‘Immaterialgüterrechtlicher Schutz von KI *de lege ferenda*’ in Markus Kaulartz and Tom H Brägelmann (eds), *Rechtshandbuch Artificial Intelligence und Machine Learning* (Beck, Munich 2020) 322.

Trabucco, Tommaso Giovanni, ‘Artificial intelligence as a tool for research and development in European patent law’ (PhD thesis, Bocconi University 2024) <https://hdl.handle.net/11565/4062472>.

Trabucco, Tommaso Giovanni, ‘The Use of AI as a Tool in Pharmaceutical Innovation and the Definition of the Skilled Person’ (LLM Thesis, MIPLC 2021).

Trask, Andrew V, “‘Obvious To Try’: A Proper Patentability Standard in the Pharmaceutical Arts?” (2008) 76(5) *Fordham Law Review* 2625.

Tritton, Guy., *Intellectual Property in Europe* (2nd edn, Sweet & Maxwell 2002).

Tull, Susan Y and Miller, Paula E, ‘Patenting Artificial Intelligence: Issues of Obviousness, Inventorship, and Patent Eligibility’ (2018) 1(5) *Journal of Robotics, Artificial Intelligence and Law* 313.

Turing, Alan M, ‘Computing Machinery and Intelligence’ (1950) 59(236) *Mind* 433.

Tur-Sinai, Ofer, ‘Beyond Incentives: Expanding the Theoretical Framework for Patent Law Analysis’ (2010) 45 (1) *Akron Law Review* 243.

Ubertazzi, Luigi C, *Commentario breve alle leggi su proprietà intellettuale e concorrenza* (4th edn, Cedam, Milan 2007).

Uhrich, Ralf, *Stoffschutz* (Mohr Siebeck, Tübingen 2010).

Ullrich, Hanns, ‘The Political Foundations of TRIPS revisited’ in Hanns Ullrich, Reto Hilty and Matthias Lamping (eds), *TRIPS plus 20* (Springer, Berlin and Heidelberg 2016) 85.

Ullrich, Hanns, ‘Legal Protection of Innovative Technologies: Property or Policy?’ in O Granstrand (ed), *Economics, Law and Intellectual Property* (Springer, Berlin and Heidelberg 2003) 439.

UNCTAD Secretariat, *The Role of Competition in the Pharmaceutical Sector and Its Benefits for Consumers* (UNCTAD, 2015) https://unctad.org/system/files/official-document/tdrbpconf8d3_en.pdf.

United Kingdom Intellectual Property Office, ‘IPO’s First AI-Powered Tool Improves Quality of TM Applications’ (GOV.UK, 15 November 2022) <https://www.gov.uk/government/news/ipos-first-ai-powered-tool-improves-quality-of-tm-applications>.

V K, Anirudh, ‘The 3 Types of Artificial Intelligence Explained’ (Spiceworks, 10 February 2022) <https://www.spiceworks.com/tech/artificial-intelligence/articles/types-of-ai/>.

van Benthem, V and Wallace, 'The Problem of Assessing Inventive Step' (1978) *IIC - International Review of Intellectual Property and Competition Law* 301.

van Empel, Martin, *The Granting of European Patents* (Springer, Berlin and Heidelberg 1973).

Vanzetti, Adriano / Di Cataldo, Vincenzo and Spolidoro, Marco, *Manuale di Diritto Industriale* (9th edn, Giuffrè, Milan 2021).

Vaver, David, 'Intellectual property: still a "bargain"?' (2012) 34(9) *European Intellectual Property Review* 579.

Verschuur, Anne-Marie / Laakkonen, Ari / Nack, Ralph / Henry, Guillaume et al., 'Summary Report, 2021 – Study Question Inventiveness and sufficiency of disclosure in AI inventions' (AIPPI, 20 July 2021).

Vertinsky, Liza, 'Thinking Machines and Patent Law' in W Barfield and U Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 489.

Vertinsky, Liza and Rice, Todd M, 'Thinking about thinking machines: Implications of Machine Inventors for Patent Law' (2002) 8(2) *Boston University Journal of Science and Technology Law* 574.

Vincent, James, 'Elon Musk and top AI researchers call for pause on "giant AI experiments"' (The Verge, 29 March 2023) <https://www.theverge.com/2023/3/29/23661374/elon-musk-ai-researchers-pause-research-open-letter>.

Viseven, 'Artificial Intelligence in Pharma Industry' (Viseven, 2024) <https://viseven.com/artificial-intelligence-in-pharma-industry/#:~:text=AI%20helps%20to%20apply%20machine,treatment%20methods%20for%20rare%20diseases>.

Volmer, Bernhard, 'Die Computererfindung: Unter besonderer Berücksichtigung des Arbeitnehmererfinderrechts' (1971) *Mitteilungen der deutschen Patentanwälte* 256.

Vowinckel, Konrad and Hähnke, Volker D, 'SEARCHFORMER: Semantic patent embeddings by siamese transformers for prior art search' (2023) 73 *World Patent Information* 102192.

Wadlow, Christopher, 'Strasbourg, the Forgotten Patent Convention, and the Origins of the European Patents Jurisdiction' (2010) *IIC - International Review of Intellectual Property and Competition Law* 123.

Wagner, Stefan, 'Patente - das schlechteste Anreizsystem für Innovationen, abgesehen von allen anderen?', in Herbert Zech et al. (eds), *Patentschutz: Impulsgeber für Innovationen oder Behinderung von Produktion?* (2021) *ifo Schnelldienst* 6.

Wagner, Stefan, 'Business Method Patents in Europe and Their Strategic Use - Evidence From Franking Device Manufacturers' (2008) 17 *Economics of Innovation and New Technology* 173.

Walch, Kathleen, 'The Increasing Use Of AI In The Pharmaceutical Industry' (Forbes, 26 December 2020) <https://www.forbes.com/sites/cognitiveworld/2020/12/26/the-increasing-use-of-ai-in-the-pharmaceutical-industry/?sh=21e81f474c01>.

Walterscheid, Edward C., 'To Promote the Progress of Science and Useful Arts: The Background and Origin of the Intellectual Property Clause of the United States Constitution' (1994) 2(1) *Journal of Intellectual Property Law* 1.

Wamsley, Cody S D, *Flashes of Genius, Toiled Experimentation, and Now Artificial Creation: A Case for Inventive Process Disclosures* (LLM thesis, The George Washington University Law School 2011) 98 http://etd.gelman.gwu.edu/etd_11165/11165.pdf.

Weber, Tomas, 'The Inventor Who Fell in Love with His AI' (1843 Magazine, The Economist, 4 April 2023) <https://www.economist.com/1843/2023/04/04/the-inventor-who-fell-in-love-with-his-ai>.

Weibust, Erik and Pelletier, Dean A, 'Protecting AI-Generated Inventions as Trade Secrets Requires Protecting the Generative AI as Well' (IPWatchdog, 24 July 2022) <https://ipwatchdog.com/2022/07/24/protecting-ai-generated-inventions-trade-secrets-requires-protecting-generative-ai-well/id=150372/>.

Weitz, Katharina, 'Was „denkt“ Künstliche Intelligenz? Wie wir sichtbar machen, wie intelligent KI wirklich ist' in Michael C Bauer and Laura Deinzer (eds), *Bessere Menschen? Technische und ethische Fragen in der transhumanistischen Zukunft* (Springer, Berlin and Heidelberg 2020) 77.

Wilding, Frances, 'Google and Samsung Top the List of Applicants for AI-related Patents at the EPO' (16 December 2021, IAM) <https://www.iam-media.com/article/google-and-samsung-top-the-list-of-applicants-ai-related-patents-the-epo>.

Wilks, Yorick, 'Machine Translation and Artificial Intelligence' in B M Snell (ed), *Translating and the Computer* (North-Holland Publishing Company 1979) 27.

Williams, Benjamin, 'The European Solution for Text and Data Mining: A Focus on the Opt-Out System Provided by Article 4 of the DSM Directive' (2021) 43(12) *European Intellectual Property Review* 786.

Williams, Kevin / Bilsland, Elizabeth / Sparkes, Andrew / Aubrey, Wayne et al., 'Cheaper Faster Drug Development Validated by the Repositioning of Drugs Against Neglected Tropical Diseases' (2015) 12(104) *Journal of the Royal Society* 1.

Willingham, A J, 'Artificial Intelligence Can't Technically Invent Things, Says Patent Office' (CNN, 30 April 2020) <https://edition.cnn.com/2020/04/30/us/artificial-intelligence-inventing-patent-officetrnd/index.html>.

Winlow, Eden, 'Patentability of AI Inventions: Updates to the EPO Guidelines for Examination' (Bristows,

2024) <https://inquisitiveminds.bristows.com/post/102j0ez/patentability-of-ai-inventions-updates-to-the-epo-guidelines-for-examination-20>.

WIPO, *WIPO Technology Trends 2021: Assistive Technology* (WIPO 2021).

WIPO, *WIPO Technology Trends 2019: Artificial Intelligence* (WIPO 2019).

Witherspoon, John F, *Non-Obviousness: The Ultimate Condition of Patentability: Papers Compiled in Commemoration of the Silver Anniversary of 35 USC 103* (Bureau of National Affairs, Washington 1979).

Wolff, Manfred E, 'Drug Discovery Market Exclusivity After KSR: The Challenge to Pharmaceutical Scientists and the US Congress' (2011) 100(8) *Journal of Pharmaceutical Sciences* 3044.

Woodhouse, Tom, 'Sufficiency of AI Inventions at the EPO' (Page White Farrer, 5 March 2024) <https://www.pagewhite.com/news/sufficiency-of-ai-inventions-at-the-epo>.

Wooldridge, Michael, *The Road to Conscious Machines* (Pelikan 2020).

Workman, Paul / Antolin, Albert A and Al-Lazikani, Bissan, 'Transforming Cancer Drug Discovery with Big Data and AI' (2019) 14(11) *Expert Opinion on Drug Discovery* 1091.

Wouters, Olivier J / McKee, Martin and Luyten, Jeroen, 'Estimated Research and Development Investment Needed to Bring a New Medicine to Market, 2009-2018' (2020) 323(9) *JAMA* 844.

Yamazaki, Toshinao, 'Patent Prosecution Highways (PPHs): Their First Five Years and Recent Developments Seen from Japan' (2012) 34(4) *World Patent Information* 279.

Yampolskiy, Roman V, 'Analysis of Types of Self-Improving Software' in J Bieger, B Goertzel, and A Potapov (eds), *Artificial General Intelligence* (Springer, Berlin and Heidelberg 2015) 384.

Yang, Xin / Wang, Yifei / Byrne, Ryan / Schneider, Gisbert et al., 'Concepts of Artificial Intelligence for Computer-Assisted Drug Discovery' (2019) 119 *Chemical Reviews* 10523.

Yang, Xuebing, 'Horizontal inventive step and international protection of intellectual property' (2013) 25 *International Review of Economics & Finance* 338.

Yanisky-Ravid, Shlomit and Jin, Regina, 'Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic' (2020) *SSRN Electronic Journal* 6.

Yanisky-Ravid, Shlomit and Liu, Xiaoqiong (Jackie), 'When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law' (2018) 39 *Cardozo Law Review* 2215.

Yelderman, Stephen, 'Do Patent Challenges Increase Competition?' (2016) 83(4) *University of Chicago Law Review* 1943.

Yoshida, Etsuko, 'Artificial Intelligence-Related Invention in Japan and Its Disclosure With a Focus on Human Intervention' in Alexandra Mendoza-Caminade (ed), *L'entreprise Et l'intelligence Artificielle - Les réponses du droit* (Presses de l'Université Toulouse Capitole 2022) 225.

Youn, Hyejin et al., 'Invention as a Combinatorial Process: Evidence from US Patents' (2015) 12(106) *Journal of the Royal Society Interface* 1.

Yu, Peter K, *Intellectual Property and Information Wealth: Issues and Practices in the Digital Age* (vol 2, Greenwood Publishing Group 2007).

Zech, Herbert, 'Brauchen wir ein Patentrecht?' in H Zech et al. (eds), *Patentschutz: Impulsgeber für Innovationen oder Behinderung von Produktion?* (2021) *ifo Schnelldienst* 3.

Zech, Herbert, *Information als Schutzgegenstand* (Mohr Siebeck, Tübingen 2020).

Zech, Herbert, 'Life Sciences and Intellectual Property: Technology Law Put to the Test' (2015) *Zeitschrift für Geistiges Eigentum* 1.

Zewe, Adam, 'Explained: Generative AI' (MIT News, 9 November 2023) <https://news.mit.edu/2023/explained-generative-ai-1109>.

Zhang, Nick, 'Moore's Law is Dead, Long Live Moore's Law!' (2022) https://www.researchgate.net/publication/360962195_Moore%27s_Law_is_dead_long_live_Moore%27s_Law.

Ziedonis, Rosemarie H, 'Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms' (2004) 50(6) *Management Science* 804.

Zingg, Raphael, 'Foundational Patents in AI' in J Lee, R Hilty and K Liu (eds), *Artificial Intelligence & Intellectual Property* (Oxford University Press 2021) 75.

Zipse, Erich, 'Computer oder nachvollziehender Mensch als Erfinder?' (1972) *Mitteilungen der deutschen Patentanwälte* 41.

Zoboli, Laura, *Diritto dei Brevetti e Intelligenza Artificiale* (Egea, Milan 2023).