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FACOLTÀ DI INGEGNERIA

Corso di Laurea Magistrale in Ingegneria Gestionale

PATENT INTELLIGENCE FOR COMPETITIVE BENCHMARKING: BREMBO CASE STUDY

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Anno Accademico 2011-2012

Autorizzazione alla consultazione della tesi di laurea

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PATENT INTELLIGENCE FOR COMPETITIVE BENCHMARKING: BREMBO CASE STUDY

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1. Introduction

The globalization of market, the increasing speed of innovation and the shortening of product life cycles require that companies carefully monitor the competitive environment in order to anticipate the future needs and technology trends. More than any other, patent information stands out as a unique source of knowledge about technical progress and innovative activity. Patents are collected, screened and published according to internationally agreed standards and provide an assessment of the state of the art in a certain technological field. They contain detailed technical information, which often cannot be found anywhere else: up to 80% of current technical knowledge can only be found in patent documents.

Patents have commonly been examined in R&D planning, from the macro-level analysis of strategy to the specific emerging technologies at the micro-level. A careful analysis of the information in patent documents highlights various facts about technologies, competitive positions, infringement risks, etc. Additionally, patents can show technological details and relationships, reveal business trends, inspire novel industrial solutions and help in deciding investments and R&D policy.

Patent intelligence – the transformation of content found in patents into technical, business and legal insight to support decision-making in technology planning – is a source of competitive advantage and can contribute to monitor competitors, forecast technology and business cycles, identify licensing opportunities and marketing strategies.

The analysis of competitors' patent portfolio is one of the principal aims for performing patent intelligence. Analyzing patent documents provides relevant information about the competitors' R&D strategy and helps to assess the competitive potential of technologies. Some important questions of technology management addressed in this context include: how can technological emerging trends in the competitive environment of the firm be detected and evaluated in advance? How can the firm's position be evaluated in comparison with the

competitors in technological fields? How can changes in the competition's technology strategy be identified?

The analysis of patent portfolio is developed principally using bibliographic data of patent documents (e.g. priority date, publication country, legal status, citations, etc.), which covers several aspects of the invention. Patent indicators can provide an objective insight of a company's patent portfolio from diverse perspectives. Recently, a new generation of patent indicators is growing, which elaborate the full patent text to extract information, such as keywords and clusters of similar patents.

To validate the proposed methodology and indicators, patent intelligence process is applied to a real-world case study. The patent portfolios of Brembo – an Italian company leader in manufacturing of brake system for automotive market – and three of its main competitors have been studied.

Patent metrics are increasingly used to assess the competitive position of technology-oriented firms. Up until now, however, very few researchers have exploited patents to anticipate the business trends. Patent intelligence approach may also be used to explore the technological condition of a new market in order to discover potential opportunities and future outcome using patents as source of information. The strength and weakness of the methodology are assessed with reference to the analysis of Chinese light vehicle market, aiming to study the technical knowledge of local car manufacturers and evaluate the implication on Brembo.

The structure of the paper and the topics of each chapter are outlined below.

Chapter 1 has introduced the importance of patents as valuable source of strategic information and set the context of patent intelligence process.

Chapter 2 gives as broad as possible an overview of intellectual property issues, focusing in particular on patents. This chapter also addresses the Chinese indigenous innovation policy, which took China to be the first country in terms of patent filings.

Chapter 3 introduces competitive and technology intelligence and shows how patents can be used as a strategic source of knowledge not just for technical information but also for business purposes.

Chapter 4 describes an important set of patent indicators for competitive benchmarking, which can be used to analyze companies' patenting strategies. The chapter explains how each patent indicator is calculated, which information can be obtained as well as its drawbacks and limitations.

Chapter 5 briefly introduces Brembo, which is the studied company and offers an outline of its intellectual property strategy.

Chapter 6 describes all the steps performed to carry out the analysis and the findings of patent indicators applied to portfolio of Brembo and its main competitors. In this chapter patent indicators are examined one by one, then are combined to study the patent portfolio on the company level and provide a comprehensive overview about competitive environment.

Chapter 7 proposes two analyses to relate patents and market data. The first combines sales data and patent application to verify the trade-off between patent efforts and market results. The latter tries to evaluate the technological condition of a market in order to identify potential opportunity and future outcome using patents as source of information.

Chapter 8 returns to a broad perspective of patent intelligence and summarizes the key findings of the paper.

2. Introduction to intellectual property

2.1 Chapter outline

Inventions, designs, trademarks and artistic works are all potential intellectual properties and may be protected by intellectual property rights. These rights are by and large granted in the contemporary society as a stimulus to creative work and innovations. This chapter gives a brief introduction to patent, utility model and industrial design right providing some basic technicalities of patenting process. It also addresses the Chinese indigenous innovation policy, which took China to be the first country in terms of patent filings.

2.2 Intellectual property rights

Intellectual property rights protect the interests of creators, or the owners, of patents, trademarks, or copyrighted work, and allow them to benefit from their own work or investment in a creation (WIPO, 2007; WIPO, 2009). The term intellectual property, as defined by the World Intellectual Property Organization, refers broadly to the «legal rights which results from intellectual activity in industrial, scientific, literary and artistic fields». Intellectual property law aims at safeguarding creators and other producers of intellectual goods and services by granting them exclusive time-limited rights to control the use made of their productions (WIPO, 2004).

The promotion and protection of intellectual property spurs economic growth, creates new jobs and industries, and enhances the quality of life. Economic development, social and cultural well-being of humanity relies on its capacity to innovate, thus governments promote progress by granting moral and economic rights to the inventors. Countries create and recognize that an efficient and equitable intellectual property system helps to foster the production of creative works, which would benefit to the whole society.

The legal protection provided by the government to the inventor has mutually benefits for both, inventors has the moral and economic rights in its creation and is encouraged to develop

further inventions, on the other side, countries promote creativity and the public can access to the disclosure and benefits from it.

Intellectual property rights are limited in many aspects, specifically limits of duration, territorial and scope. These limits vary depending on the form of intellectual property one is referring to. Despite the different form of intellectual property rights protect different kinds of work, each one has a duration limit (e.g. 20 years for patent), is valid only in the country where is registered and cover only what is disclosed. Intellectual property is commonly divided into two branches, "industrial property" and "copyright". Generally speaking, the first term includes inventions, industrial designs, trademarks and geographic indications of source, while the latter refers to the areas of literary, artistic and scientific works, such as novels, plays, films, musical works, drawings, paintings, etc.

2.3 Patent for invention

«Any person in this city who makes any new and ingenious contrivances not made heretofore in our Dominion, shall, as soon as it is perfected so that it can be used and exercised, give notice of the same to the office of our Provveditori di Comun, having been forbidden up to ten years to any other person in any territory and place of ours to make a contrivance in the form and resemblance of that one without the consent and license of the author.»
Venetian Statute on Industrial Brevets, Venice (1474)

The birth of patent law may be traced back in 19 March 1474, when the Venetian Senate passed the first general patent law. The Venice Patent Statute has often been celebrated as the first comprehensive patent law that introduced the basics principles of modern intellectual property rights, it anticipates in some way the modern requirements of patentability and the rights granted by the patent (Kostylo, 2008).

The Venetian law was the first to provide a statutory basis for the patent system. It introduced the idea that grants ought to be based on invention's characteristics rather on the relationship between the applicant and the authority. The patent law required that the new device or practice, for which a patent was requested, might be granted for "any new and

ingenious device", providing that it "can be used and exercised" (i.e. useful). These criteria of novelty, inventiveness and utility anticipate the modern requirements of patentability and still remain as basic principles of patent law.

Equally significant, the Venice Patent Act forestalls the rights granted by the patent, since it protected the inventions against copy or unauthorized use. Furthermore, the Venice patent was limited in time (i.e. «up to ten years») and territorial extension (i.e. «any territory and place of ours»). Similar limitations can be found in the contemporary patent law.

The modern patent law originated from the Venice Statute and developed through centuries to reach the current international conventions, which establishes the guidelines for national law.

2.3.1 Definition

Patents provide inventors with legal rights to prevent others from making, using, selling or importing their inventions for a fixed period of time, normally twenty years (Dutfield & Uma, 2008). The World Intellectual Property Organization defines a patent as a «document, issued, upon application, by a government office (or a regional office acting for several countries) which describes an invention and creates a legal situation in which the patented invention can normally only be exploited (manufactured, used, sold, imported) with the authorization of the owner of the patent» (WIPO, 2004).

As every form of intellectual property, patents are limited in time. The agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) establishes that «the term of protection available shall not end before the expiration of a period of twenty years counted from the filing date». TRIPS agreement is administered by the World Trade Organization (WTO) and sets down minimum standards for intellectual property regulation. Since almost every country is part of WTO[1], the time limit of a patent can be considered, generally, of twenty years.

Furthermore, the territorial scope of a patent is limited. A patent is valid only in the countries in which the protection has been requested, the rights of the inventors are recognized from the

[1] http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm, for an up-to-date list of the WTO members.

national, or regional, patent system in which the patent application was filed. No intellectual property rights can be enforced outside of the national, or regional, jurisdiction.

The third limit is the patent scope, which strictly depends of the invention disclosed in the patent application. More precisely, patent claims are the part of patent application that describes the invention and defines the scope of protection conferred by a patent, in other words the claims delineate the boundaries of the patent owner's rights. In case of patent infringement, the allegedly infringing product or process is compared to the claims of the patent. Therefore, they are of the utmost importance during both prosecution and litigation.

In general terms, an invention is defined as a product or a process that offers a new solution to a technical problem in a specific field of technology. An invention can be either the creation of an entirely new product or process, or an improvement of an existing solution. Not all inventions are patentable; law requires that an invention must fulfill certain conditions of patentability in order to obtain protection.

2.3.2 Conditions of patentability

In a large number of countries, patents are granted after an examination that verifies whether the invention meets the requirements for being eligible of patent protection. Basically, the invention must be new, industrially applicable and it must exhibit a sufficient "inventive step".

2.3.2.1 Novelty

According to WIPO, an invention is considered new if it is not part of the state of the art, which is all the knowledge available to the public before the filing of the patent application. The disclosure of an invention may take place by describing it in a published writing, in an oral form in public or by the use of the invention in public. All patent systems give the right to patent to the first person to file a patent application, except United States, which gives the right to the first inventor. The United States, which had traditionally followed a policy of recognition of the first inventor, have recently planned to shift from a "first to invent" to a "first to file" system with the America Invents Act (AIA) (USPTO, 2012).

2.3.2.2 Inventive step (Non-obviousness)

The requirement of inventive step determines whether or not the invention «would have not been obvious to a person having ordinary skill in the art» (WIPO, 2004) and is, perhaps, the most difficult to assess in the examination. An invention must fulfill the requirement of novelty, and then it could meet the requirement of inventive step. In order to satisfy this condition, the invention must have a "considerable step" resulting from a creative idea over the prior art.

2.3.2.3 Industrial applicability

In order to be patentable, an invention must meet the industrial applicability criteria, meaning that it must have a practical purpose. Any pure theoretical or aesthetic activity is excluded. Even so, the term "industrial" should be considered in its broadest sense, including any kind of industry.

Paris Convention for the Protection of Industrial Property sets an extensive meaning of the term "industrial". As stated in Article 1(3), «industrial property shall be understood in the broadest sense and shall apply not only to industry and commerce proper, but likewise to agricultural and extractive industries and to all manufactured or natural products» (WIPO, 2007).

National and regional laws and practices concerning the industrial applicability requirement vary significantly. At one end, the requirement of industrial applicability is met as long as the claimed invention can be made in industry without taking in account the use of the invention. At the other end, the "usefulness" of the claimed invention is considered for the determination of the industrial applicability.

2.3.2.4 Additional requirements

In addition to these requirements the invention must consist of patentable subject matter and the disclosure in the application must be clear enough to be understood from an expert in the field.

Theoretically, according to TRIPS Agreement «patents shall be available for any inventions […] in all fields of technology». Nevertheless, patentable subject matter is established by national law and is defined in terms of exceptions to patentability. The TRIPS Agreement provides the guidelines regarding subject matter that may be excluded from patentability. Due to the fact that patent law is a matter of national jurisdiction, the government may exclude from patentability inventions against public order or morality. Consequently, most of the countries have excluded from patentability diagnostic, therapeutic and surgical methods for the treatment of humans or animals, and have limited the patentability of plants, animals and other micro-organisms. The national nature of the patent law gives rise to discrepancies of patentable subject matter between the countries.

Countries grant patents to applicant in return for a sufficient disclosure of the invention, which could benefit to the progress of society. For this reason, an additional requirement of patentability is a sufficient description of the disclosed invention. A patent application must explain the invention «in a manner sufficiently clear for the invention to be carried out by a person skilled in the art» (WIPO, 2004). The invention must be described completely and, where appropriate, the description must be supported with drawings and examples; it must be also provided at least one embodiment of the invention.

2.3.3 Patent application and prosecution

In order to obtain the grant of a patent, an applicant, either legal (i.e. company) or natural (i.e. person), must file an application at a patent office in the geographic area over which coverage is required. A patent application is a request pending at a patent office for the grant of a patent for the invention described and claimed by that application. Patent applications can be filed either in national patent office or in regional agency acting for several countries, such as the European Patent Office. Since every country has a national jurisdiction about patent law, the formal procedure, times and costs for obtaining a patent vary among countries. However, it is possible to identify few common steps in the procedures of different countries.

Before applying for a patent it must be drafted a patent specification, a document detailing the background, description and embodiments of the invention and the claims, which define the scope of the protection. Afterwards, the patent application must be filed at a patent office and will undergo both a formal and substantial examination, which is the patent prosecution phase.

The patent prosecution phase consists of the interaction between applicants, or their attorney, and patent authority. Broadly, patent prosecution can be split into pre-grant prosecution, which involves the reply to examiners negotiating for the grant of a patent, and post-grant prosecution, which involves issues such as post-grant amendment and opposition.

The first application for a particular invention filed at any patent office becomes the priority application, with the date of this event defining the priority date. The priority filing provides the patent applicant with a grace period (i.e. one year from the priority date) to file patent applications for the same invention in other patent jurisdictions without loss of the novelty requirement for patentability. The following applications may claim the priority of the first. The patent office location of the first filing is defined as the priority country.

A patent is the right granted to an inventor by a State, or by a regional office acting for several States, which allows the inventor to exclude anyone else from commercially exploiting his the patented technology within the legal jurisdiction of the authority that granted the patent – e.g. a valid Italian patent may be enforced only in Italy and nothing could be done against a company that sells counterfeit product in Germany (WIPO, 2007). Hence, inventors must file applications for a patent in each jurisdiction where they foresee a need for protection.

Patent applications are published 18 months after the earliest priority date. Prior to the publication, the application is confidential to the patent office. However, the applicant could request for an anticipated publication and notify the invention to third parties. The publication of a patent application marks the date at which it is publicly available and therefore at which it forms full prior art for other patent applications worldwide. Once the patent application has been published the applicant may request the substantial examination, which will verify whether the patent specification meets all the requirements (i.e. novelty, inventive step and industrial

applicability). The examiners will compare the invention with the prior art to assess all the conditions of patentability and, if necessary, may ask the applicant to modify the claims (e.g. to restrict the patent scope).

Finally, if the invention satisfies all the requirements, the patent office will grant the patent. Once the patent has been granted, it is valid and can be enforced and the patent prosecution phase begins. During this period (i.e. from the grant until the expiry of the patent), the applicant has to pay periodic renewal fees to keep the patent alive, without which the patent will lose its validity. Furthermore, the patent can be used against counterfeiter in patent litigation, the legal proceedings for infringement of a patent.

2.4 Utility model

In a number of countries (e.g. in Italy and in Germany), inventions are also protectable through a registration less strict than patent, called "utility model" or "short-term patent". The regulations on utility model are not standard and unified all over the world as for patent law, therefore utility patent features (i.e. requirements, duration, costs, etc.) varies among countries.

In comparison with the inventive step necessary to obtain a patent for invention, the technological progress required is smaller. The maximum term of protection provided is generally shorter than patent for invention, although the duration varies among countries, ranging from five to fifteen years. Usually, even the application and renewal fees are lower.

2.5 Industrial design

An industrial design – also named design patent – is an intellectual property rights that protects the ornamental or aesthetic aspect of an article. A design may consist of a shape or a surface of an item or a two-dimensional pattern. Industrial designs are applied to a wide range of products: from technical and medical instruments to watches, jewelry, and other luxury items, from housewares and electrical appliances to vehicles and architectural structures.

Under most national laws, the requirements for industrial design are novelty and originality, which are determined with respect to the existing design corpus. An industrial design covers the aesthetic nature and does not protect any technical features of the article to which it is applied. As for utility models, the duration of protection, application procedure and costs vary slightly among countries depending on national legislation.

2.6 Patent Law of the People's Republic of China

2.6.1 History and development

In 1978 China marked a key turning point with the "open door policy", hence the patent law was strongly supported to facilitate Chinese development into an innovative country, to raise the wealth of society and to comply with its international obligations (Lifang, 2004). Patent law in modern People's Republic of China was promulgated on 12th March 1984 and became effective from 1st April 1985 (SIPO, 2009). Patent law introduced two new types of patents (i.e. utility model, and design patent) and the gap with the international standards was significantly reduced. China has amended its patent law in 1992, in 2000 before joining World Trade Organization and becoming member of the TRIPS agreement (Wang & Xuming, 2006) and, most recently, in 2009.

The target of enhancing the capacity of indigenous innovation and building an innovative country put forward by the National Congress of the Communist Party of China and the evolution of international agreements required further improvements of China's patent legal system. Therefore, in 2005 the Chinese Patent Office initiated the revision process, which terminated on 1st October 2009 when the newly revised patent law came into force. The major changes of the revision to the patent law include: to enhance the threshold of patentability, to provide regulations on the protection of genetic resources and to improve the confidentiality examination system for applications to a foreign country (SIPO, 2010).

Chinese Patent Law confers the official authority of the State Intellectual Property Office to take charge of patent related matters. The central government agency (SIPO), together with its own local branches, is responsible for examining and grating patents.

Chinese patent rights can be categorized in three distinct forms: patent for invention covers new, or improved, technical solution for a product or a process; utility model patent is granted for new solution relating to the shape or the structure of a product; industrial design patent protects the aesthetic aspect of an item.

As in Europe, Chinese Patent Office follows a "first-to-file" policy and grants the patent to the applicant who first files the application. The protection provided by a patent for invention lasts twenty years from the date of filing, or from the earliest priority date, and the criteria of patentability reflects the European requirements. To be patentable under Chinese law, an invention shall be are «novel, creative and of practical use», which is roughly the same of European patent law. Despite of these similarities, Chinese patent law requires that domestic entities or individuals intended to apply for a patent in a foreign country for invention or utility model made in China submit the matter to the national patent authority for confidentiality examination (SIPO, 2009).

2.6.2 Chinese utility model

The Chinese utility model protects any new technical solution concerning the shape of a product, which is fit for practical use, the protection provided lasts for ten years and is not submitted to substantial examination. Utility model is designed to be relatively cheap, quick and easy to obtain and is suitable to inventions having a short commercial life and hence are very popular with Chinese domestic innovators. In 2010, 409˙836 utility models were filed at Chinese Patent Office, 99.4 % by domestic innovators. Conversely, foreign companies do not use this kind of protection for their inventions; according to SIPO statistics foreign companies have filed just 2˙598 utility models (SIPO, 2012).

The Chinese Patent Law recently underwent its third revision and the new amendment provides that only one patent may be granted for one invention. Where both an invention patent and a utility model patent are applied for, the patent for invention may be granted only if the utility model patent is abandoned at the time the invention patent is granted. Since a utility model will be granted much faster than invention patent, a potentially useful and strategically valuable route for protection of inventions would be to file both simultaneously to benefit from the speedy granting of utility model first, then abandon in favor of the longer protection offered by the patent for invention when granted (Stembridge, 2010).

2.7 Indigenous innovation policy

Since the Chinese economic reform started in 1978, China has moved from a closed, centrally planned system to a more market-oriented country that plays a major global role – in 2010 China became the world's largest exporter. Nowadays it is undergoing an increase in land prices, environmental and safety regulations and taxes and, above all, labor cost, which may lead to the end of cheap China. In March 2012, The Economist wrote that «the old stereotypes about low-wage sweatshops are as out-of-date as Mao suits» (The end of cheap China, 2012).

Chinese leaders had recognized that they need to move from "Made in China" to "Designed in China" to face the rising costs, making products with higher margins and offering services to complement them. The changing has already began: government heavily supports innovation in both public and private sector, companies are trying to hire high-skilled people from all over the world and the upward trend of Chinese patent applications shows their commitment for innovation.

In the last decade China pursued a policy of "market for technology", which encouraged foreign company to transfer technology in return for market opportunities. The strategy was successful in stimulating rapid growth and in helping to make the country the manufacturing center of the world – China accounts for a fifth of global manufacturing in 2011 – but meanwhile it creates a strong dependence on foreign technology. Despite the remarkable

economic performance, its achievements in commercial technology field are not equally satisfactory (Cao, Suttmeier, & Simon, 2006). Chinese companies have always played the role of "followers" – or even worse, "counterfeiter" – in the market, because they benefit from low labor cost rather than innovation. However, Chinese leaders had recognized that being the world's low-cost workshop has its limits and they are trying to build an economy that relies on innovation rather than imitation.

Chinese government has understood that those who own intellectual property and control technical standards enjoy privileged positions and earn most of the profits. Thus, the Chinese industrial economy of the 21st century should set its own standards and generate and incorporate its own intellectual property in order to take advantage from innovation. In order to improve its innovation capability, Chinese government introduced, in January 2006, a strategic plan that established the guidelines aimed at increasing level of scientific and technological innovation originating within the country and intended to reduce dependence of foreign technology. China's innovation policy is laid out in the "Medium-and-Long-Term National Plan for Science and Technology Development" (MLP), issued by China's State Council and developed to foster domestic innovation. MLP sets the goals for China to become an «innovation-oriented society by the year 2020, and a world leader in science and technology (S&T) by 2050». According to the MLP, China will invests 2.5% of its increasing GDP in R&D by 2020, raise the contributions to economic growth from technological advance to more than 60% and limit its dependence on imported technology to no more than 30%.

The 15-Year Plan has been supplemented by other policy statements, all recognizing the importance of intellectual property (Liang, 2012). In 2008, State Council of the People's Republic of China issued the "Outline of National Intellectual Property Strategy", which was «formulated for the purpose of improving China's capacity to create, utilize, protect and administer intellectual property, making China an innovative country». More concretely, the strategy encouraged companies and universities to develop their intellectual property. The Outline of National Intellectual Property Strategy also includes benchmarks, proclaiming that

by 2013: «China will rank among the advanced countries of the world in terms of the annual number of patents for inventions granted to the domestic applicants, while the number of overseas patent applications filed by Chinese applicants should greatly increase».

The National Intellectual Property Strategy was followed by National Patent Development Strategy, published by SIPO in November 2010. It was formulated for the purpose of thoroughly implementing the National Intellectual Property Strategy, enhancing China's capacity to create, utilize, protect and administer patent. China admits there is still a gap between the patent landscape and the demand for economic and technological development, the National Patent Development Strategy is a long-term plan for enhancing China's core competitiveness by making use of patent system (SIPO, 2011). Chinese government has created a system of incentives to promote domestic innovation. A number of measures have been taken to foster patent filings – tax reduction for Chinese firms that file many patents, tenure for university professors and *hukou* (residence permit) to live in a desirable city for workers and students – moreover, patent application fees are subsidized by local governments.

The National Patent Development Strategy sets ambitious goals for China – e.g. reach 2 million of patent filings by 2015 and become one of the top five countries in the world in the number of invention patents granted. The strategy pursued by China had led to a dramatic increase of Chinese patent application. In 2008, Thomson Reuters published a report about «the present and future state of innovation in China» describing the Chinese patent boom. According to Thomson Reuters, Chinese patent applications grew, from 2003 to 2007, at an average rate of 34.3% per year and it foresaw that China would «dominate the patent information landscape in the not-too-distant future» (Zhou & Stembridge, 2008). Thomson Reuters was right.

An analysis of patent application volumes over the last five years (2007-2011) shows that inventions from China have been growing at a faster rate than any other region. The average annual growth rate of patent applications in China over the period 2007-2011 was of 21.42%, whereas Europe and United States lay far behind, the growth rate of patent application in these countries was respectively 1% and 2.5%. China had surpassed the number of applications filed

in Europe[2] and in Korea in 2005; it overtook Japan in 2010 and United States in 2011, becoming the first patent office for number of application (Orlando, 2013).

There are several indicators that can be used to identify and track innovation trends. The total volume of patent application gives a first estimate of the total patenting activity in a region. Application numbers are a sum of direct filings and PCT national phase entries received by offices (Fig. 2.1).

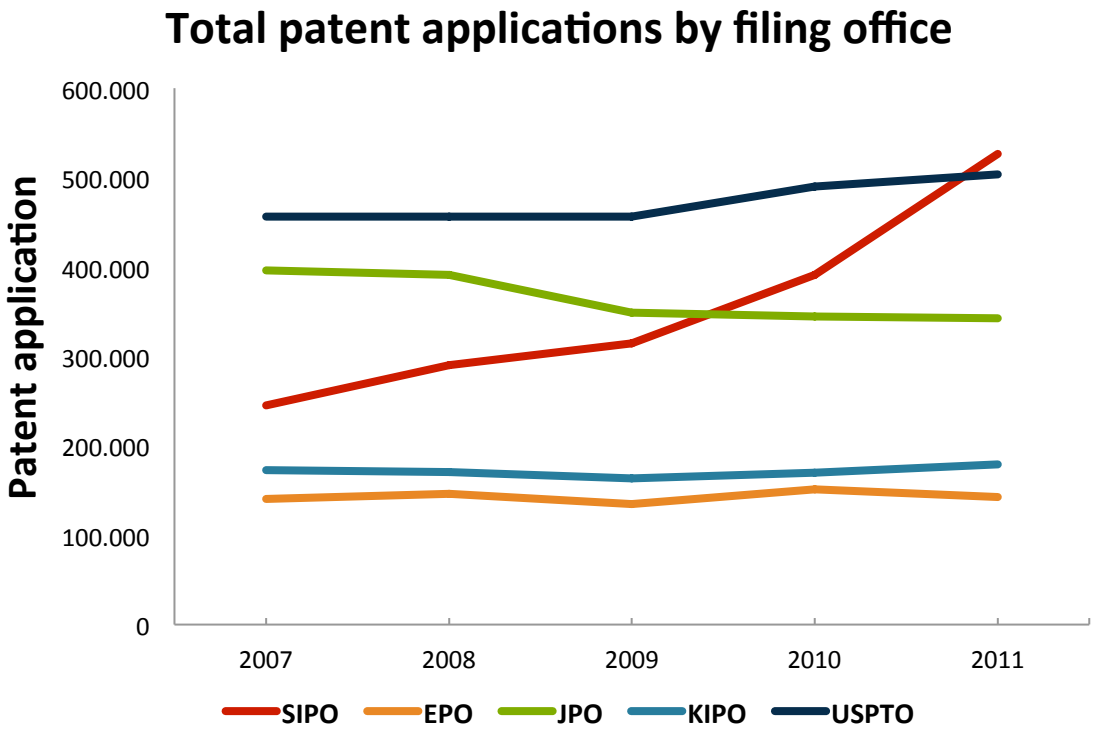

Fig. 2.1 - Total patent applications by filing office
Source: WIPO Statistics Database

The sharp growth of Chinese patent application has resulted in an increase of Chinese granted patents. Although patent grants per year are rising, China is still far from the number of grants of United States and Japan (Fig 2.2).

[2] Referring to European Patent Office.

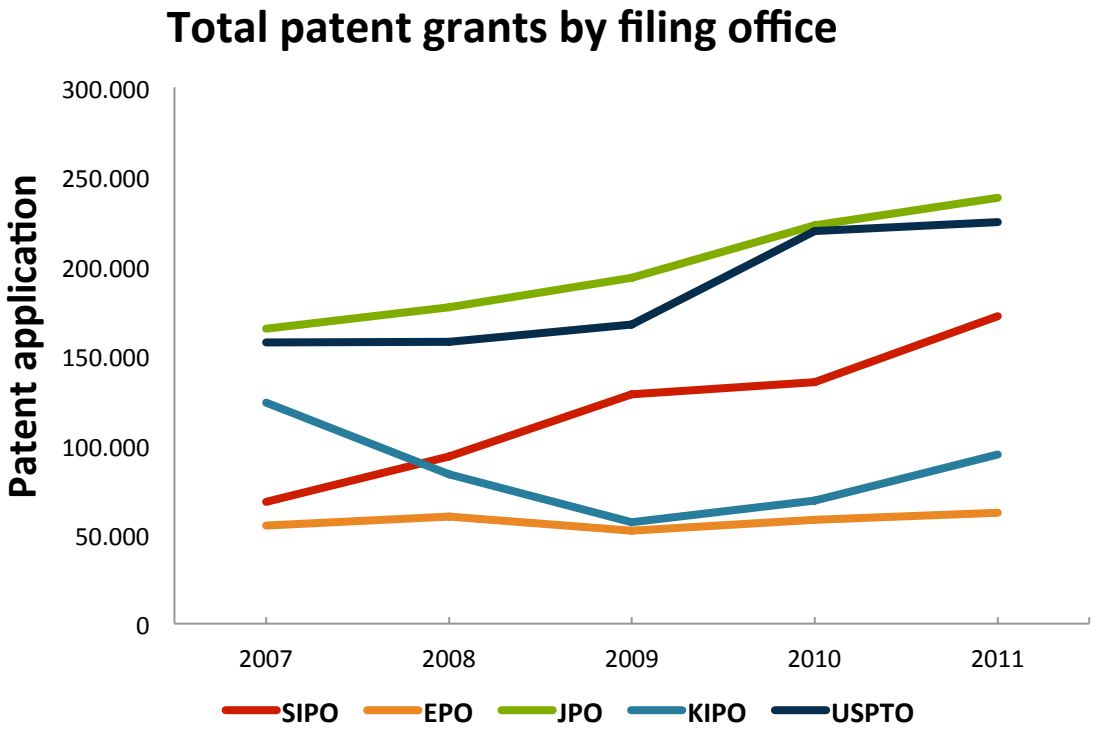

Fig. 2.2 - Total patent grants by filing office
Source: WIPO Statistics Database

Patent application and patent grant counts involve two aspects: inventions patented from a domestic applicant and those other from foreign applicant, for which protection is sought in order to manufacture, use or sell the invention in the region. The number of domestic patent applications provides a measure of home-grown innovation. According to annual report from the State Intellectual Property of P.R.C. (SIPO), in 2011 the number of domestic patent applications kept increasing at high rate (SIPO received 526˙000 invention patent applications, 416˙000 of which were domestic invention patent applications, accounting for 79% of the total). Among all valid invention patents, domestic inventors own 50.4% of the total. In 2011 the number of all valid domestic patents exceeded the number of patents owned by foreign applicants for the first time (SIPO, 2012).

China has developed its economy in the past years, and the increase in patent filing reflects the progress. Nevertheless, the explosive growth of patenting activity in China may be a misleading indication of its capacity for innovation. The correlation between innovation and

number of patent applications is hardly one-to-one and the burst of Chinese patenting activity is strongly promoted by governmental policy. Incentives for applicants facilitate patent filings, but may make it worthwhile for companies and individuals to patent even worthless ideas. «Patents are easy to file» says a Chinese patent attorney, «but gems are hard to find in a mountain of junk» (Patents, yes; ideas, maybe, 2010). There are reasons to doubt about the quality of the patents being applied for and granted in China and hence, the degree to which the patent data represents real progress in innovation.

2.7.1 Quality of Chinese patents

In April 2011, the Organization of Economic Cooperation and Development conducted a study of patent quality across its member nations and a few other countries, including China (OECD, 2011). The study collected data for all patents granted by the European Patent Office between 2000 and 2010, by applicant's residence country and calculated a patent quality index. The index is a composite indicator that tries to capture both the technological and the economic value of innovations, and is based on patent's information, such as citations, claims, patent renewals and patent family size. China ranked 27 out of 28 countries, demonstrating an average patent quality lower than other countries (Fig. 2.3).

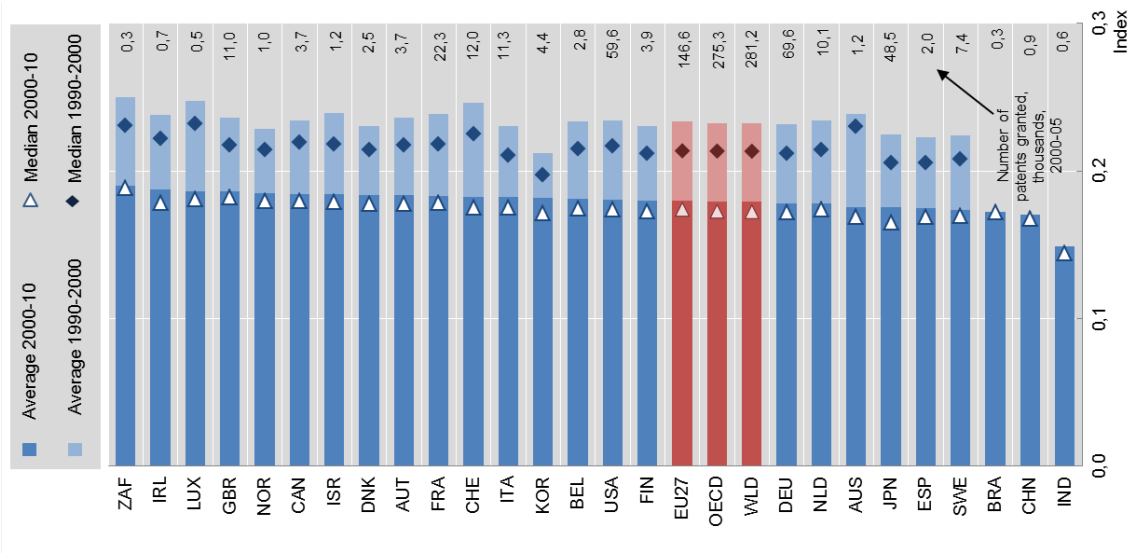

Fig. 2.3 - Patent quality index by country, 1990-2000 and 2000-2010
Source: OECD Science, Technology and Industry Scoreboard 2011

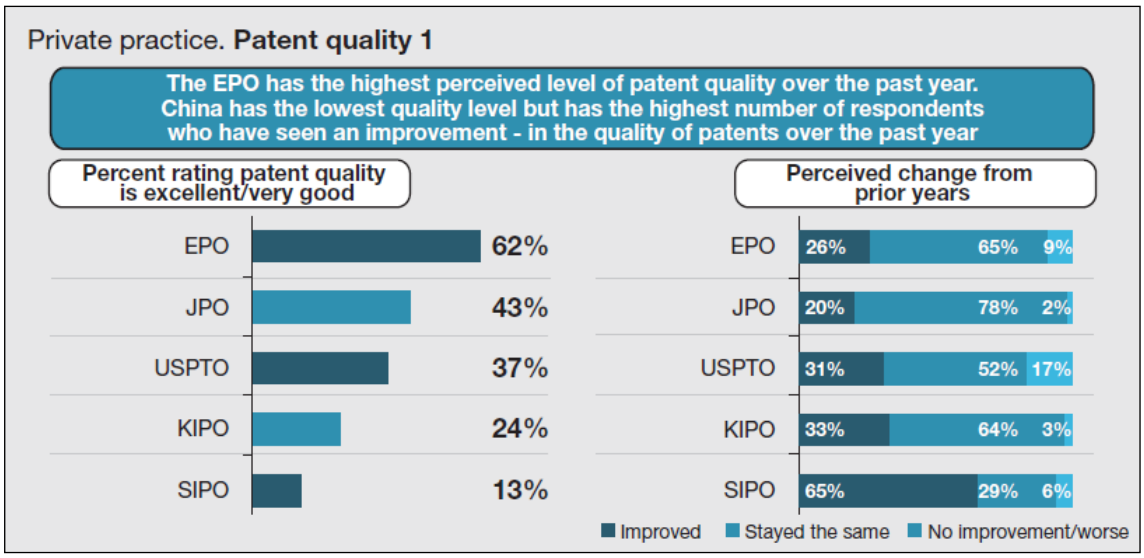

Fig. 2.4 - Performance of patent office according private practice
Source: IAM/Thomson Reuters survey

Similar concerns about Chinese patent low-quality came from a survey conducted by Thomson Reuters and Intellectual Asset Management (Wild, 2011) to investigate the opinion of lawyers and in-house counsels about the five major patent offices (EPO, JPO, USPTO, KIPO and SIPO). Fig. 2.4 and 2.5 illustrate the results of the survey.

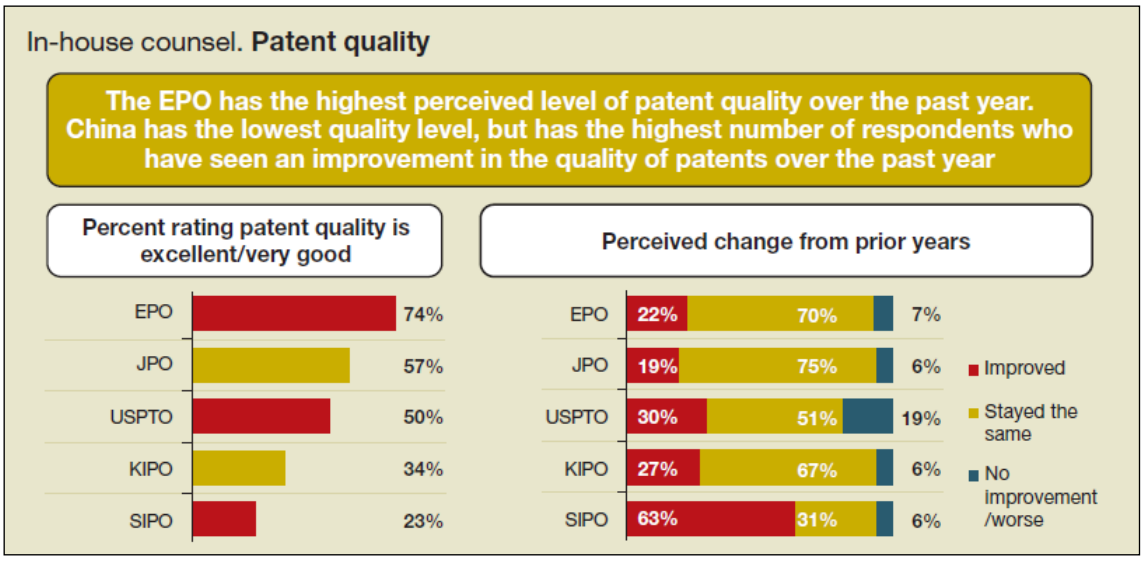

Fig. 2.5 - Performance of patent office according in-house counsel
Source: IAM/Thomson Reuters survey

The EPO has the highest perceived level of patent quality over the past year (62% from private practice and 74% from in-house counsel), whereas Chinese patent office has the lowest quality level (13% from private practice and 23% from in-house counsel). However, SIPO has the highest number of respondents who have seen an improvement in the quality of patents over the past year. On average, 64% of respondents have seen an improvement of the SIPO patent quality over the past year, 30% perceived the same quality and just the 6% did not observe any improvement or even a worsening of the performance.

China last-place in the survey and the limited recognition of Chinese-origin patents abroad provide grounds for concern about Chinese patent quality and lessen the astonishing growth of patent filings.

3. From competitive to patent intelligence

3.1 Chapter outline

Patents are a useful source of knowledge about technical progress and innovative activity, therefore have commonly been examined in R&D planning, from the macro-level analysis of strategy to the specific emerging technologies at the micro-level. A careful analysis of the information in patent documents highlights various elements of knowledge about technologies, competitive positions, infringement risks, etc. Additionally, patents can show technological details and relationships, reveal business trends, inspire novel industrial solutions and help in deciding investment and R&D policy. Patent analysis is a source of competitive advantage and can contribute to monitor competitors, forecast technology and business cycle, identify licensing opportunities and marketing strategies. This chapter introduces competitive and technology intelligence and describes how patents analysis can be used as a helpful instrument to achieve goals of intelligence process.

3.2 An overview of competitive intelligence

In an increasingly complex and fast-moving economy, companies must be able to develop new knowledge to maintain high-levels of innovation and gain a competitive advantage. Numerous factors of risk are emerging alongside traditional ones: the globalization, the high-rate of technological development and the recent financial crisis are just few of them. The modern market-dominated economy and the industrial issues facing businesses have increased considerably in complexity. The fierce competition in the market requires anticipating the technology trend and competitor's strategy. To remain competitive, a business must be able to manage its intangible assets.

Competitive intelligence is an approach and organizational process that allows a company to be more competitive, through surveillance of the environment (Ghalamallah, Luobuer, & Dousset, 2011). Organizations have always gathered information about competitors, but

competitive intelligence goes one step further and sets up a structured process of managing relevant data. Porter identified the need for a competitor intelligence system and laid the foundation of modern competitive intelligence (Porter, 1980). Since that, competitive intelligence greatly developed adding analysis techniques and information sources to the practitioners' toolbox (Prescott, 1995).

There are numerous definitions of competitive intelligence in contemporary practice and scholarship but none of them is likely to be precise and universally accepted. As such, competitive intelligence is generally viewed as a systematic and ethical process by which organizations gather actionable information about competitors and the competitive environment and apply it to their planning process and decision-making in order to improve their enterprise's performance (Fleisher & Bensoussan, 2007). The borders of the notion of competitive intelligence are still unstable and, over the last few years, more and more definitions have emerged, with a perceptible shift from definitions based almost exclusively on processes and techniques toward definitions including the strategic aims (Ghalamallah, Luobuer, & Dousset, 2011). Additionally, it must be clarified that competitive intelligence relies on publicly available data, any information used origins from legal source, conversely of industrial espionage which makes use of illegal techniques (Brody, 2008). Among others aims, competitive intelligence process can be used to assess the technological scenario surrounding the firm as well as to forecast new disruptive technologies.

3.3 From competitive to technology intelligence

3.3.1 Technology intelligence: a helpful approach

The globalization of market, the increasing speed of innovation and the shortening of product life cycles require that companies carefully monitor the competitive environment in order to anticipate the future needs and technology trends. Whether perceived, monitored and managed timely and effectively, technological changes can be a business opportunity for

companies. Conversely, external technology development can be a threat if they are not adequately perceived and managed (Arman & Foden, 2010).

Technology is an important strategic asset for many companies, and technological consideration must be included in strategic planning process (Phaal, Mitchell, & Probert, 2003). A proper strategic technology planning can enable companies to anticipate potential technology-based risk and opportunities and react in time to benefit. A technology assessment of competitive surrounding environment provides to company the relevant information to take technology-based decision, in order to minimize the risk of inappropriate technology investment and gain as much as possible from the opportunities within the key developing technology areas. Technological change is a major factor in gaining competitive advantage. Promoting innovation, exploiting technological opportunities and avoiding threats are fundamental activities. Firms need to recognize both current and potential future technological advances that can affect their products and processes. Technology management is necessary to support strategic management for the technology-related decisions and to create competitive advantage by linking technology to business. Within the framework of technology management, the technology intelligence process should be utilized to identify promising technology, to show their potentiality and their limits, and to gain competitive advantage from technological change (Arman & Foden, 2010). Successful managers know that their companies must keep abreast of developments in their fields, but do not have a systematic way to collect the relevant information of technology change from the flow of information around them (Ashton & Stacey, 1995). Traditional monitoring processes in most companies are largely arbitrary, depending on what concerned individuals in the organization are reading, thinking and sharing informally with each other, but in today's world such arbitrary process is inadequate (Patton, 2005).

The activity of collecting and evaluating information on technology developments has been given several names, including technology intelligence (Arman & Foden, 2010). The interpretation of the term technology intelligence is multi-faceted (Lichtenthaler, 2003). Other terms used are technology forecasting (Zhu & Porter, 2001; Jun, Park, & Jang, 2012)

technology monitoring (Porter, Roper, Mason, Rossini, Banks, & Wiederholt, 2011), technology scouting (Brenner, 1996) and competitive technical intelligence (Norling, 2000).

According to Lichtenthaler (2003), the goal of technology intelligence is to exploit potential opportunities and to defend the firm against potential threats, through prompt delivery of relevant information about technological trends in the environment of the company. Technology intelligence encompasses the activities related to the collection, analysis and communication of relevant information on technological trends to support strategic decisions of the company. Technology intelligence process includes the monitoring and analysis of individual competitors as well as universities and start-up companies.

3.3.2 Four essential steps of technology intelligence process

In the existing literature, many different technology intelligence processes are discussed (Cleland & King, 1975; Norling, 2000; Lichtenthaler, 2004). In spite of their relative dissimilarities and evolution over time, the basic process steps are 1) the determination of information needs, 2) information acquisition, 3) information analysis and 4) information communication.

The process begins with the determination of the intelligence requirements and the organization of the resources for information collection, in this stage is important to plan, organize and direct the technology intelligence effort.

The collection phase include the preparation and the carrying out of a collection plan as well as the storage of relevant information. Since the quality of the results strictly depends on the information collected it is important to give the uttermost attention to the reliability of sources and the gathering process. Information is not intelligence until it has been processed and analyzed.

A number of methods to process information are described in literature. Some authors categorize them between normative and exploratory methods or qualitative and quantitative methods; others have identified factors that allow selection of an optimal method in order to

obtain an assessment as accurate as possible. In many situations, however, the choice is restricted by the time and the resources available. Once the intelligence is derived it could be disseminated to the managers and decision-takers entitled to receive it.

Input for the technology intelligence process may come from a variety of sources, both public and private. The sources of data are so numerous and varied that it would be impractical to list all of them. As representative are reported business and technology periodicals, academic and scientific publications, patents, consultant and external experts, market research, product fairs, collaborative networks, customers and suppliers, government sources, etc.

3.3.3 Technology intelligence methods

Lichtenthaler (2005) investigates the evolution of technology intelligence methods and the intensity of their use across different industries. According his research, it exists a broad spectrum of technology intelligence methods. The classic methods known already from 1970s, such as scenarios analysis, quantitative conference analysis, experience curve, flexible expert interviews and expert panels are intensively used. Currently, their use is often so tightly integrated into the process of strategic technology management that they are no longer perceived as specific methods of technology intelligence. Also the indicator-based methods developed in the 1980s, such as patent and literature frequency and analysis, are known and have been tested as an instrument of technology intelligence. Typical uses for these methods are the analysis of competitors and the open scanning for new technologies. R&D has become more market oriented since 1990s, which is why methods used take strongly into account market and competitive aspects. Road-mapping and quality function deployment methods allow a bi-directional translation of customer needs to technological solutions. Lead user analysis are intensively used in market-driven industries, their main goal is to identify the innovation needs of key customer. Benchmarking and portfolio analysis have been fruitfully introduced in R&D, where are used to compare internal R&D activities with the global state-of-the-art, and particularly with the direct competitors. At the end of 90s, the interest in managing uncertainty

concerning the outcome of R&D projects and of external trends resulted in the developing of options pricing models.

For all of these technology intelligence methods should be decided the proper assessment form. An assessment form encompasses the appropriate type of assessment, either individual or in group, and the appropriate person performing the analysis. The choice of assessment forms and technology intelligence methods is influenced by various contingency factors (e.g. the function and the time horizon of the assessment) (Lichtenthaler, 2005).

The methods may be grouped according the function of the assessment (Table 3.1). Two groups of functions can be distinguished: information generation and learning. The first is aimed at generating detailed knowledge about the future. Trend identification and competitor analysis are essentially aimed at assessing potential future opportunities and threats. Concerning the future-oriented information generation, three forms can be distinguished: extrapolative, explorative and normative information generation. The extrapolative techniques project past and current developments into the future and try to sketch the most probable picture of the future. The explorative information, in contrast, is aimed at identifying possible future developments to predict different possible pictures of the future. The final goal is not to identify the most probable future scenario but to generate reliable strategies by studying possible future changes. The normative information generation is aimed at analyzing a specific picture of the future and at identifying possible ways that may lead to it. In contrast to the role of information generation, the function of learning aims at increasing the number of possible actions through internalizing information. Concerning the use of technology intelligence methods as instruments of organizational learning, it can be distinguished techniques oriented to individual or group learning. The relevance and appropriateness of the technology intelligence methods is also affected by the time horizon that firms would like to investigate. Different methods are suitable for different time horizons ranging from five to twenty-five years.

Table 3.1 - Technology intelligence methods and their relevance for different functions of assessments
Source: The choice of technology intelligence methods in multinationals: towards a contingency approach, Lichtenthaler, 2005.

	Information generation		
	Extrapolative	Explorative	Normative
Publication analysis	•		
Quantitative conference analysis	•		
Patent analysis	•	•	
Scenario analysis		•	•
Benchmarking studies	•		•
Delphi and expert panels	•	•	
Roadmaps	•		
Experience curve	•		•
Lead user analysis	•	•	
Quality function development	•		
Options pricing models		•	

3.4 Using patent information for technology intelligence

Patents are an important source for technology intelligence with which enterprise can gain strategic advantage (Shih, Liu, & Hsu, 2009). In literature, the activity of analysis of patent information has been referred to with several definitions. Patent competitive intelligence emphasizes the capability to assess the company's internal and external patent landscape (Kirsch & Brown, 2006). The term "patinformatics" describes the science of analyzing patent information to discover relationships and trends, which would be difficult to see when working with patent documents on a one-on-one basis (Trippe, 2003). Trippe explains patinformatics as a macro-level science, an analysis that deals with large quantities of patent information. Patinformatics comprises all macro-level forms of analyzing patent information including:

- Patent intelligence defined as the use of information to identify technical capabilities of an organization and the use of findings to develop a strategy for technical planning (Trippe, 2003). Recently, patent intelligence acquired a broader meaning. It has been defined as the transformation of content found in patents into technical, business and legal insight to support decision-making in technology planning (Park, Kim, Choi, & Yoon, 2013).

- Patent mapping uses published patent data to create a graphical representation of the state-of-the-art pertaining to a particular subject area. Patent map provides a visualized expression of technological information in patent documents (e.g. chart, graph or table), allowing complex patent information to be understood easily (Lee, Yoon, & Park, 2009) (Japan Patent Office, 2011).
- Patent citation analysis refers to the study of patent citations for potentially determining patent's value, potential licensing partners and to determine key-patent and important cluster in a specific technology field (Karki, 1997).

Additionally, researchers have used the term patent management for technology forecasting, indicating that patent analysis can be performed to predict future technological developments. (Jun, Park, & Jang, 2012).

In this paper, patent intelligence is understood as a process, which comprises the collecting and analysis of information disclosed in patent documents aiming to create and communicate knowledge about internal and external environment. Each previous definition should be considered. Since goals and tools are taken from patent intelligence process, citation analysis is used to measure the relevance of a patent document and patent mapping is essential to disseminate intelligence efficiently.

More specifically, patent analysis can be used to indicate:

1. company's and competitors' technological profile, strength, weakness and positions in various technologies and markets. Knowledge of competitors' patent portfolio enables monitoring their innovation strategy at an early stage. This is useful for company benchmarking as well as for identifying strategic groups of companies with similar patent strategies, new entrants or technological actors in general;
2. technological conditions and changes (e.g. trends, fluctuations, convergence, transitions, maturity, etc.), linkages to other technologies and sciences, fertile R&D directions, likely strategic patent positions and revival of old technical ideas. The tendencies of patenting

activity show which fields have been abandoned by the industry players and the areas they are currently concentrating on (Granstrand, 1999);

3. new technology opportunities by studying patent density and exploiting undeveloped technological fields (Lee, Yoon, & Park, 2009);
4. suitable target for technology acquisition through M&A, joint ventures, R&D collaboration.
5. existing technical solutions to avoid wasteful duplication in R&D effort;
6. licensing in/out and cross-licensing opportunities (Campo dall'orto, Conti, & Gatti, 2003);
7. hire-overs of key inventors (The British Library, 1998).

3.4.1 Patents as valuable source of strategic information

Granstrand distinguishes between four types of technical information carriers[3]: 1) patents, 2) publications, 3) people (that is, S&T professionals) and 4) products/processes (S&T artifacts) (Granstrand, 1999). Patent information, despite its many and well recognized inadequacies, stands out as a unique source of technical information. More than any other source, it is collected, screened and published according to internationally agreed standards. It continually provides an assessment of the state of the art together with at least a rudimentary measure or metric of technological change. The inadequacies of patent information originate from different companies' attitude towards patent, discrepancies in patent system and patent office behavior. Despite of these lacks, patent system is the most prolific and up-to-date source of information on applied technology. Patents contain detailed technical information which often cannot be found anywhere else: up to 80% of current technical knowledge can only be found in patent documents. Many companies do not disclose their R&D results in any other form; furthermore, patents are available even for companies that are not required to publish R&D figures. Looking up patents is an efficient way to avoid duplication of R&D efforts: EPO estimates that up to 30% of all expenditure in R&D is wasted on redeveloping existing inventions. Since the patent

[3] A *technical information carrier* is meant as an entity that carries technical information or knowledge. Technology in products and professionals is sometimes called embodied technology, while patents and publications carry disembodied technology.

system was established, more than 60 million of patent documents from all over the world have been published. All documents are uniformly classified according to the International Patent Classification scheme (IPC), which eases the analysis of specific technological aspects and can be freely accessed via Internet (European Patent Office, 2007). The upcoming of patent databases have greatly enhanced the possibilities for companies to search and access patent documents. Many patent offices already allow free download of the complete texts of their patents – e.g. Patentscope (WIPO), Espacenet (European Patent Office). Finally, in comparison to other information source, patents are often the only source for the timely recognition of technological changes (Ernst, 1998).

A patent document contains dozen of items for analysis, which can be grouped into two categories[4]. The first includes structured items, which are uniform in semantics and in format across patents, such as patent application number, filing date, issued date or assignees. While the latter encompass the unstructured items, meaning they are texts of contents, such as the description of invention (Tseng, Lin, & Lin, 2007).

Patents are a unique source of information and the importance of patent data as a reference for competitive intelligence has been acknowledged from time (Shih, Liu, & Hsu, 2009). Patent documents are also crucial for research, development and business strategies, even for companies without intentions to apply for patents of their own (Ruotsalainen, 2008). However, patent information should be combined with information from other data sources, such as publications, seminars, workshops, informal contacts, etc. Combining patent data with other types of information turns out to be an effective strategy, since it allows achieving complementary knowledge of the company and the business context (Granstrand, 1999).

3.4.2 Characteristics of patent intelligence

Patent frequency and patent citation analysis are known and have been tested as useful instruments of technology intelligence. Typical uses for these methods are the analysis of

[4] For a more detailed description of patent information see the Appendix 1

competitors and the open scanning for new technologies. Patent intelligence collects data from patent documents and transforms into relevant business information, thus is accounted as an information generation technique aimed at producing detailed knowledge about the future. Methods with this function can be categorized in extrapolative, explorative and normative. Patent intelligence encompasses both extrapolative and explorative function. By looking at competitors' patent portfolio, patent intelligence attempts to outline their R&D and market strategies. As extrapolative techniques, translates past and current developments into the future and thus tries to develop the most probable picture of the future.

Patent-based analysis is also seen as an explorative method due to its trend-identifying character, able to recognize emergent technology and new player entering in the market. Here, it is not used to generate robust strategies by studying possible pictures of the future. It is considered particularly suited for the short-to-medium term forecasts, ranging from five to ten years. Traditionally, patent analysis has been categorized as a quantitative method since it relies principally on structured bibliographic data (e.g. priority year, publication country, etc.). Despite that, the latest text mining techniques enable to study unstructured patent information, such as abstract, description and claims, adding qualitative features to the analysis.

In the study carried out by Lichtenthaler across technology-intensive companies from the pharmaceutical, telecommunications equipment and automotive industry it arises that, in the pharmaceutical industry, patent analysis is only used to competitor assessment, because this indicator does not show relevant technological trends early enough, while in the other two industries is regularly used. Further, automotive companies employ patent analysis to map competitors and to identify new technologies (Lichtenthaler, 2005).

3.4.3 Differences with patent search

Traditionally, patents were monitored only by intellectual property advisors, but there is a rising interest of business, product and research manager towards the analysis of patent documents. Companies hire analysts, consultants, and licensing experts to help them with R&D

strategies, patent portfolio management and technical intelligence (Hunt, Nguyen, & Rodgers, 2007). Anyway patent intelligence should not be confused with patent searches.

Patent search, also called prior art search, is an attempt to find evidence of patents or technical publications in order for an attorney to assess patentability, novelty, clearance or infringement risk. Its purpose is to find technologically relevant material to address a specific legal need. Patent search and patent analysis rely on the same types of databases and searching techniques, but distinguish for their aim. While the purpose of the first is to assist the attorney with a legal opinion during patent prosecution or litigation, the latter extends its goal to a strategic purpose, (e.g. solve a business or research problem, locate licensing opportunity, support marketing initiative). Both patent search and patent analysis should be conducted by a patent-specialist due its knowledge of patent database and searching techniques, but are addressed to two different kind of audience. Patent searches are directed to attorneys and agents, while patent analyses are for research, product and sales managers, therefore synthesis and visualization of the key data is essential.

3.4.4 Limitations of patent intelligence

Critics would point out that patents often not prove to be sufficient or not reproducible at all, and would furthermore only allow a temporally delayed perspective on the R&D landscape due the 18 months gap between the filing date and the publication date of a patent application (Fabry, Ernst, Langholz, & Köster, 2006). In the present hyper-competitive environment, companies try to reduce the time to market, thus the product could be ready for commercialization before the patent would be publicly available.

In terms of insufficient reproducibility of individual patents, this opinion may be correct. However, the majority of all patents – around 85% – are no longer in force, meaning that a vast number of inventions are available for free (European Patent Office, 2007). Furthermore, the infringement risk is usually restricted to a concrete individual case and does not deal with aggregated patent information.

The argument of 18-month lag between application and publication cannot be sustained on closer consideration. Generally, patents are not filed when the development has been finished, but at a much earlier point in time. This procedure is a necessary practice as it is the only way to protect the development from the beginning. Furthermore, taking into account that researchers – specially those coming from industrial fields – would not report their latest results in any other way, patent application offer a very prompt insight into the R&D strategy of a company despite of its 18 months delay.

According to the requirement of unity of invention, a patent application can relate only to one invention, or at least a group of closely related inventions, so the correlation between invention and patent must be strictly one-to-one. Conversely, inventions, and consequently patents, are not immediately connected to products available in the market. Hence, even an accurate knowledge of a competitor's patent portfolio does not give the opportunity to know which products will effectively adopt the patented technology. Furthermore, it should be kept in mind that not every R&D outcome will become a patent application, the majority of results would not produce any interest results and others will not be published. Some information will always remain confidential to company (e.g. trade secrets).

4. Patent intelligence for competitive benchmarking

4.1 Chapter outline

The analysis of competitors' patent portfolio is one of the principal aims for performing patent intelligence. Analyzing patent documents provides relevant information about the competitors' R&D strategy and helps to assess the competitive potential of technologies. Some important questions of technology management addressed in this context include: how can technological emerging trends in the competitive environment of the firm be detected and evaluated in advance? How can the firm's position be evaluated in comparison with the competitors in technological fields? How can changes in the competition's technology strategy be identified? (Ernst, 2003).

This chapter clarifies how patent information can be used for competitive benchmarking and describes which patent indicators can be used for this purpose. It explains how they are calculated and which information can be drawn as well as their drawbacks and limitations.

4.2 Patent indicators

Until today, a variety of patent indicators have been proposed in literature. Patent indicators have been used as a proxy of firm's market value (Hall, Jaffe, & Trajtenberg, 2006). Triadic patent families methodology (i.e. patent family filed in United States, Europe and Japan) has been adopted to evaluate country's economic performance in a specific technology field (OECD, 2011). Citation analysis has been used as an indicator of relative importance of the patent (Trajtenberg, 1990; Karki, 1997; Harhoff, Narin, Scherer, & Vopel, 1999). Finally, patent indicators have been combined to benchmark competitors' patent portfolio (Fabry, Ernst, Langholz, & Köster, 2006).

Patent indicators are based principally on structured data of patent documents (e.g. priority date, publication country, legal status, citations, etc.); therefore they can provide an objective insight of a company's patent portfolio from different perspective. Recently, a new generation

of patent indicators is growing. They elaborate the patent full text to extract information, such as keywords and cluster of similar patents and their results can be represented in a patent map. Furthermore, the upcoming of patent databases has greatly enhanced the possibilities of systematic data retrieval on a large scale and the automated computation of patent indicators make them particularly interesting, since they provide useful information at limited cost.

Patent fields can provide different strategic information, which can interest different area of an organization. As shown in Table 4.1 patent data can offer a numerous of contents related principally to R&D, marketing, intellectual property and human resources management.

Table 4.1 - Strategic information provided by patent data

Patent data	**Informative content**	**Area of interest**			
		R&D	Marketing	IP Strategy	Human resources
Priority date	- Measure level and changes of R&D efforts - Measure volume and changes of patent activity - Evaluate portfolio or technology maturity	•		•	
Publication country	- Evaluate geographical distribution and market trends - Size international scope of patent portfolio - Identify products specifically developed for regional market	•	•		
Applicants & Inventors	- Reveal collaboration network and active patentees - Hire over of key-inventors	•			•
Classification	- Discover core technologies - Forecast technology evolution - Compare technology interest	•			
Title, abstract, claims	- Inspire novel industrial solution - Cluster similar patents	•		•	
Citations	- Identify key patents for licensing opportunities - Show complementary and substitute companies - Measure technology distance from competitors	•		•	
Legal status	- Appraise commitment in prosecution phase - Anticipate infringement risk - Avoid duplication R&D efforts	•		•	

Table 4.2 - Patent indicators for competitive benchmarking

Patent data	Patent indicator	Definition	Metric
Priority date	Distribution by priority year	Count of patents by priority year	# patents / year
	Portfolio maturity	Calculate patent age and group for different time-span	year
Publication country	Distribution by priority country	Count of patents by priority country	# patents / priority country
	Distribution by publication country	Count of patents by publication country	# patents / publication country
	Trilateral filings	Number of patents filed in Europe, United States and Japan	# patents
	Quadrilateral filings	Number of patents filed in Europe, United States, Japan and China	# patents
Applicants & Inventors	Top inventors	Select most frequent inventors	Ranking of inventors
	Top applicants	Select most frequent applicants	Ranking of applicants
	Collaboration networks	Identify co-developed patents and link applicants according the number of shared inventions	Weighted directed graph
Classification	Top IPC Codes	Select most frequent IPC Codes	List of IPC Codes with number of patent / IPC Class
	Distribution by IPC Codes	Count of patents for each IPC Code	Relative share of IPC Code
	Technology scope	Count of IPC Codes for each patent	# IPC Code / patent
Title, abstract, claims	Cluster of patents	Text mining and clustering techniques	Statistic measures of similarity
Citations	Top cited patents	Select most frequently cited patents	Ranking of cited patents
	Top cited applicants	Select most frequently cited applicants	Ranking of cited applicants
	Self-citing ratio	Ratio of self-citations on all citations	Percentage
Legal status	Distribution by legal status	Count of patents by legal status	# patents / legal status
	Grant success rate	Ratio of granted patents on all patent applications	Percentage

Based on the same categories of patent data, Table 4.2 summarizes an important set of patent indicators, explaining how they are calculated and the metric of results. In the next section each patent indicator will be discussed, explaining how is calculated and measured and which

information can be obtained as well as its drawbacks and limitations. The following indicators should be applied to a patent collection created for competitive benchmarking. Generally, all indicators are more informative if their dynamic development over time is analyzed.

4.2.1 Distribution of patent applications by priority year

The firm's patent activity in a technological field is an immediate and fundamental patenting indicator. Patent activity is calculated as count of annual priority application and is based on priority date field. The distribution of patent applications by priority year measure the level of R&D efforts and the variation of firm's patent activity can be interpreted as a change in R&D strategy.

Patent activity provides information also regarding the intellectual property management of a company. A comparison between annual number of priority filing and economic highlights of comparable companies offers an indication of interest in patent protection.

Unfortunately, these indicators do not care about the "quality" of patent, thus it is important to consider them along side with others indicators that keep into account the relevance of patents. As every patent indicator, it is available 18 months after the filing date, due to the publication delay of patent.

4.2.2 Portfolio maturity

The patent portfolio maturity gives an overall indication on the patent age and help to evaluate R&D strategy pursued by the applicant in the past. Portfolio maturity is calculated from the earliest priority date of patent family, which provides an accurate indication of invention's age. Complementarily, years to expiry measure the remaining life of the patent family. The average age of patent portfolio expresses its maturity but to obtain a more detailed indicator patents can be grouped according a range of different timespan (e.g. patents can be divided in 5-years timespan). The analysis of maturity on patents concerning the same technology allows evaluating its development stage. For example, established technologies have

a considerably high number of patents and a slow innovation pace, while emerging fields are still mostly uncovered and has an elevated number of annual filings.

4.2.3 Distribution of patent applications by priority country

The analysis of country of first filing outlines the company's patenting and marketing strategy. It is a common practice to file a patent in the domestic country, then improve the invention in the 12-months grace period and, if it turns out to be successful and marketable, apply for protection in foreign countries. This indicator is defined as count of patents according priority country. Additionally, a product specifically developed for a foreign market can be protected only in that countries, consequently also the priority application would be filed abroad. Thus, patent filed first in a foreign country can reveal specific business strategy. Typically, priority filings are made in the corporation's headquarter country. Therefore, different priority countries may be due to collaboration with other firms or patents acquired by external source.

4.2.4 Distribution of patent applications by publication country

A single patent only provides a statutory monopoly for the patented invention within the legal jurisdiction of the authority that granted the patent. This means that inventors must file applications for a patent in each country where they foresee to produce or sell the invention. The number of jurisdictions in which patent protection has been granted for the invention is used to calculate the size of patent family, an indicator of the value of patent right (Harhoff & Reitzig, 2004). Whereas the distribution of applications filed in different patent authorities reveals company's geographic business distribution and provides clues on potential markets for the patent-protected product. Preliminary information on applied countries is available 18 months after the filing date, but can still change during the prosecution stage. In case of PCT application, information on protected-country will be definitive 30 months after the earliest priority date.

4.2.5 Trilateral and quadrilateral filings

Traditionally, trilateral – also named triadic – patent families were defined by OECD as a set of patents taken at the European Patent Office (EPO), the Japanese Patent Office (JPO), and the US Patent and Trademark Office (USPTO) that share one or more priorities (Dernis & Khan, 2004). Further, quadrilateral filings are those that have been additionally filed at the Chinese Patent Office (SIPO). Trilateral and, especially, quadrilateral filings require significant funding due for translation and local agent counsel in three – or four – territories. Trilateral or quadrilateral filings are an evidence of the intention to produce or commercialize the products related to the invention in a global manner and their evolution over time shows geographical trends linked to the market strategy. These indicators are often used as a statistical measure of the international scope of patent portfolio.

4.2.6 Top applicants and top inventors

By sorting the number of patent by applicant is possible to select the top companies, which are the most active patentees in a specific technology field. In the same way, studying inventors field allows to identify key-inventors. Information on patentees can be useful to plan R&D activities, finding suitable partners for collaboration and to human resource recruiting.

4.2.7 Collaboration networks

An invention developed by two or more organizations usually results in a patent filed together, indicating as applicant all the involved entity. The analysis of applicant field can identify co-developed patents and link partners together according the number of shared inventions. It can be represented as a directed graph with weighted connections. This indicator reveals network of collaborations, partnership between companies, universities and research centers.

4.2.8 Top IPC Codes

The technology class is the only structured field related to the technical content disclosed in the patent. Every application is sorted according to one or more patent classification scheme,

which is used to organize and index the technical content of patent specification. International Patent Classification (IPC) is a worldwide-recognized standard and virtually every patent has an IPC code. IPC is a hierarchical system and consists of sections, classes, subclasses and groups. Sections are the broadest level of structure and each lower level is progressively more specific. IPC level should be defined according to the technological scope of the analysis, choosing between sections, class, groups depending on the broadest of the technology field considered. For instance, an overall study of a country's key technology areas may consider class level, because several classes would be included; while a detailed analysis of a specific field should deal with more descriptive IPC groups.

IPC codes provide a number of information on a firm's R&D and technology strategy. Selecting the most frequent IPC code is possible to identify the core technologies of the underlying portfolio and, jointly with IPC evolution over time, forecasts the technological trend.

4.2.9 Distribution of IPC Codes

Studying IPC Codes clearly shows the "hot areas" of the patent collection, however, it is hard to distinguish the technology focus of a firm. The share of principal IPC codes within company's portfolio can provide a better insight of its technological focus. Moreover, it is possible to compare the patent portfolios of different firms and measure the distance between their technology interests.

4.2.10 Technological scope

The best way to measure patent scope might be through subjective assessments; unfortunately this approach requires the help of patent attorney and technicians, and the analysis of just few patents often takes several weeks. Such an effort did not appear a practical way to develop a sample of sufficient size for an empirical analysis. Instead, Lerner suggests employ a proxy for patent scope: the number of IPC classes into which patent authorities assigns the patent (Lerner, 1994).

4.2.11 Cluster of patents

All the previous indicators make use only of "first page information", that is structured data, uniform in semantics and in format across patent documents, such as filing dates, citations, classification and so forth. A number of bibliometric techniques have been developed to manipulate and analyze these data. However, patents contain also unstructured data, texts of various length and contents (i.e. title, abstract, description and claims of the invention). Despite they are lengthy, rich in technical terminology and require a lot of human efforts for analyses, if carefully examined, they can show technological details and relations, anticipate business trends, inspire novel industrial solutions and help make investment policy. Recently, there has been an interest in applying text-mining techniques to assist the task of patent analysis and patent mapping. A proper usage of the full text information in patent documents may complement the interpretations derived from patent structured data (Tseng, Lin, & Lin, 2007).

Text mining is a modern technique that has been proposed to perform knowledge discovery from collections of unstructured text. In relation to patent analysis, it is used as a data processing and information-extracting tool. Since the original patent documents are expressed in natural language, it is necessary to transform raw data into structured data. Then, the process of keyword extraction is applied to identify the principal concepts and to measure similarity between patents (Yoon & Park, 2004). The outcome of text mining techniques consists primarily of a set of cluster (i.e. groups of patent documents that show similarity in the subject matter) and should allow for the extraction of information regarding patenting trends (Fattori, Pedrazzi, & Turra, 2003). The results of statistical analyses and text mining processes applied to patent documents can be visualized as patent maps, which allows to create a representation of information from and about patent documents in a way that is easy to understand. It is an excellent tool for assessing large sets of patent data. (EPO, 2010)

Indicators compiled from the patent full-text seem to have two major advantages and one major disadvantage over traditional indicators. By analyzing the technical content disclosed in patent documents with text-mining techniques, they provide an in-depth analysis of technical

content which otherwise would not be feasible with the ordinary study of classification scheme. Furthermore, they are attractive since they are available early in time (immediately after the publication of the patent) and since they show a strong theoretical foundation. Their disadvantage lies in their endogeneity, i.e. that the patent document is drafted by the proprietor (or his attorney) who has the opportunity to infer on the value of his patent by the personal mode of drafting the document (Reitzig, 2004).

4.2.12 Top cited patents

Patent citations can be divided in two main kinds:

- backward citations refer to the preceding literature and are made by the applicant or by the examiner to identify the prior art and compare it with the invention. The cited references are mainly previously issued patents although they may also be journal articles, scientific literature, etc.;
- forward citations are the references of a patent in subsequent patent or non-patent literature. In general, 70% of all patents are either never cited, or cited only once or twice, so five citations place a patent in the top few percent of cited patents.

The key idea behind patent citation analysis is that a highly cited patent is likely to contain an important technological advance, thus the count of citations is an indicator of the technological impact of the patented invention (Karki, 1997) (Trajtenberg, 1990).

The top cited patents of a company's portfolio or a business sector can be considered as the key patents. Thanks to the identification of key patents, companies can enhance their intellectual property management and evaluate licensing opportunities. Licensing out permits to make profit form intellectual property assets, whereas licensing in allows acquiring technology from external source.

4.2.13 Top cited applicants and self-citing ratio

Patent citation analysis is also an established and useful competitive intelligence tool. Patent citations counts can be used to identify technical complementarities or substitutes among

patenting firms. Many techniques of competitor assessments like citing and cited patents, citation impact, technology profiles and maps have been discussed in literature and authors shown that ratio and ranking obtained from patent citation analysis can uncover interesting clues. Similarly, the analysis of cited and citing applicants can be used to determine which companies are working closest to key technology and can be a measure of "technological distance" between the competitors. Finally, the ratio of self-citations on total citations made by an applicant indicates whether the company has continued to improve upon earlier inventions or has progressively changed technology field.

However, forward citations are available with a considerable delay. First, a patent application is comprised in the state-of-art only after publication (i.e. typically, 18-months after first filing). Second, timespan is required before the filings of newer patent applications upon the same technical problem or with similar technical features. Third, even the citing patent application will be available eighteen months later. Therefore, the availability of data regarding forward citations is about forty months after the filing date (Reitzig, 2004). The number of forward citations will increase during the patent lifetime and the forward citations-based indicators will be more accurate after some years.

4.2.14 Distribution of patent applications by legal status and grant success rate

Legal status data relates to legal events in the lifetime of patent (e.g. grant, abandon, expiry, etc.). Distribution of patent applications by legal status provides an indication on the number of rights effectively enforceable and of patents abandoned, expired or revoked. Typically, these data are essential to determine infringement risk but could be useful to avoid duplication of R&D efforts. The review of state of the art before starting a new project can anticipate risk and allows saving time and money by not reinventing the wheel.

From a patent intelligence perspective, legal status analysis allows distinguishing valid and enforceable patents from dead application or expired patents. Since a patent must undergo a substantial examination in order to be granted, the ratio of granted to filed patents – also named

grant success rate – is a proxy for technological quality of patent portfolio. Furthermore, legal status offers information about the prosecution stage, revealing the interest and the commitment by the company in patent applications.

Basically, a patent right can be alive or dead. The possible legal status for an alive patent is:

- granted, patent authority examined and accepted the patent application, the right is valid and enforceable;
- pending, patent application is waiting for examination by patent office.

Whereas, legal status for a dead patent can be:

- lapsed, patent application is no longer valid in a country due to the failure to pay renewal fees or to reply to the examiner;
- revoked, protection terminated for lack of patentability requirements;
- expired, patent protection has terminated its duration.

4.3 Patent portfolio benchmarking

All the patent indicators presented above can be used to analyze companies' patenting strategy from different perspective (e.g. technology, marketing, human resources, etc.) and provide an interesting in-depth assessment of the characteristic of patent portfolio. However, they are always related to a specific field and fail to provide an overall view of the patent portfolio. Ernst (1998) describes patenting strategies of companies according two different dimensions: patent activity and patent quality. Patent activity measures the level of R&D activities, whereas patent quality measures the impact of these activities. The number of patent applications is a fundamental indicator of company's patent activity, while patent quality is measured by calculating an index of patenting indicators. The value of patent information is greatly enhanced if varying levels of patent quality is taken into account, including several indicators of patent quality reduces the variance of measurement errors. In literature several indicators has been identified as measures of patent quality (Ernst, 2003) (Ernst, 1998). Following Ernst (2003) these indicators should be used: 1) grant ratio; 2) technological scope;

3) international scope and 4) citation frequency. The share of granted patents results from the legal status analysis and is calculated as the granted patents of the firm in a specific technology field on all firm's patent applications in that field. The technology scope is based on the average count of IPC Codes assigned to patents. The grant ratio and the technological scope measure the technological quality of the firm's patent application. On the other hand, international scope and citations frequency are indicators of economic quality. International scope of a patent application can be sized through the number of patent family members and the share of triadic patents. Patent citations have been widely recognized in literature as a measure of economic value (Harhoff, Narin, Scherer, & Vopel, 1999) (Trajtenberg, 1990). Specifically, Ernst suggests using average citation frequency as a proxy of economic value of patent application. Nevertheless, age-weighted citations frequency needs to be calculated in order to avoid distorted results due to patent age. In order to assign a systematically higher weight to old patents, the citation frequency should be measured relatively to the citation frequency of an average patent from the same year (Ernst, 2003). Patent quality consists of the sum of relative measures for each of the above-described indicators of patent quality. Relative values are calculated by relating the firm's indicator to its mean value over all assessed firms. Similarly to patent quality, the company's patent activity is measured by the number of its patent application to the average number of the whole set. The patenting behavior can be categorized into four different types of patenting strategies (Fig. 4.1). Active patentees of high-quality patents are located in the upper-right quadrant, they can be considered as the technological leaders within the industry. Companies with less patent activity are classified as selective patentees of high-quality. Usually, smaller companies are located here. Those companies do not file many patents; however, their technological potential ought not to be underestimated, since the quality of their patent is high. Therefore, the patenting behavior of these companies needs to be observed and examined carefully in technological competitor monitoring.

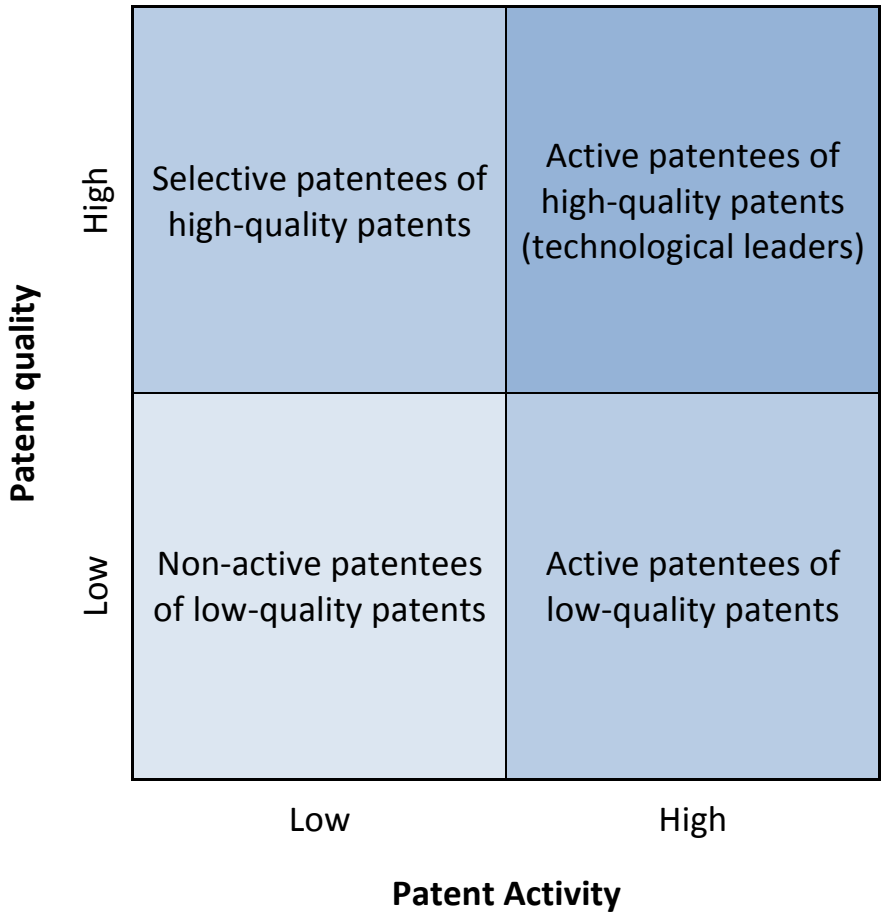

Fig. 4.1 - Identification of patenting strategies in a patent portfolio on the company level
Source: Patent portfolios for strategic R&D planning, Ernst, 1998

If companies are located in lower quadrants of the patent portfolio, they should basically reassess their R&D activities or try to improve the patenting strategy. Technological positions have been identified and evaluated by means of analyzing overall positions in patent portfolios on the company level. This allowed an assessment of the activity level of overall R&D efforts and its differentiation according to the achieved quality of the overall position relative to the competition. Furthermore, relevant competitors with respect to their patenting strategy as an origin of potential technological threats for a company can be identified.

The benchmark of patent portfolio shows the competitive position of a firm in a technological field, facilitates the identification of leading firms and the measurement of technological distance among competitors. These indicators should become a core element of balanced scorecards for top management and decision-makers.

5. Brembo case study

5.1 Chapter outline

The patent intelligence process described in the preceding chapters will be applied to Brembo, an Italian-based company, renowned brake system supplier for premium and racing cars. This chapter briefly introduces Brembo and offers an overview of intellectual property in Brembo.

5.2 Brembo Spa

Brembo is an Italian manufacturing company and an acknowledged innovation leader in the field of automotive disc brake technology. The company supplies high performance braking systems to the premier manufacturers of automobiles, motorcycles and commercial vehicles worldwide, as well as clutches, seats and harness for the racing sector. Brembo has an unrivaled prestige in motorsport competition, with more than two hundred world championship titles won in the role of original equipment supplier.

Brembo pursues a strategy of international expansion to establish and strengthens its presence in the countries where its clients have production plants, in order to supply products more rapidly and efficiently. Today, Brembo is a fledged multinational company with operations in three continents and production facilities in sixteen countries. The group has a workforce of about 7˙000 employees, approximately 10% of whom are engineers and product specialists engaged in R&D activities. Sales turnover in 2012 amounted to 1˙388.6 million €.

Brembo has always paid close attention to innovation topic. As a matter of fact, it promoted Kilometro Rosso Science and Technology Park. Started up in 2007, Kilometro Rosso hosts companies with a highly inventive outlook, as well as scientific institutes and research centers operating in the most advanced fields, promotes dialogue between the academic, entrepreneurial and scientific environment. It is a multidisciplinary center that makes diversity a strength point

and encourages cooperation by adopting a cross-competence approach to explore the new frontiers of science and technology.

5.3 History

Brembo was founded in 1961 just a few kilometers outside Bergamo by Emilio Bombassei and Italo Breda. The founders start as a small mechanical workshop and in 1964 started the production of first Italian brake disc for the spare part market. Soon afterwards, production activities were broadened to include other braking system components, additionally the expertise of the company and the quality of its products earned international recognition. The greatest evidence of the quality and technology of Brembo products came in 1975, when Enzo Ferrari chosen Brembo to equip the most prestigious racing cars in Formula 1. Since then, countless teams using Brembo brakes have won hundreds of world championships in every possible automobile and motorcycle racing category.

From the beginning of the 1980s, Brembo focused on developing innovative products and processes, with a strategy of expansion in specialized areas of the market from passenger cars to motorsports and motorcycles. The product range was expanded adding an aluminum brake caliper for vehicles, which was revolutionary in both design and the materials used. This new caliper was gradually adopted by high performance car manufacturers, such as Porsche, Mercedes, Lancia, BMW, Nissan and Chrysler. Furthermore, Brembo decided to extend its operations into the industrial vehicle disc brake segment, becoming a strategic supplier for Iveco, Renault Industrial Vehicles and Daimler. In 1983, Brembo was partially acquired by Kelsey-Hayes, a United States-based multinational braking systems manufacturer. Through this collaboration Brembo could grow and consolidate itself in preparation for the challenges of the future.

In 1993, as a consequence of a new strategic orientation, Kelsey-Hayes withdrew as a shareholder in the company. Brembo focused its energies on the future of the company, drawing strength from the expertise of the managerial personnel and technological superiority. In the

following years the company continues to grow and in 1995 the company went listed on Piazza Affari, the Italian Stock Exchange.

Brembo starts the new millennium with a strategy of market expansion achieved by acquiring complementary companies and investing in new production facilities. Firstly, Brembo acquired the Brazilian company Alfa Real Minas for the machining of automobile brake discs and the assembly of engine flywheels, then Brembo acquired AP Racing Limited, a British company that produce brake and clutch systems for high performance cars and motorcycles. To strengthen its presence in the motorcycle market, Brembo acquired 70% of Marchesini, an Italian company involved in the production of magnesium wheels for race motorcycles. Brembo Group's activities recently extended to include the design and production of passive safety systems, with the acquisition of Sabelt, an Italian producer of car outfitting and technical clothes for racing market.

5.4 Brembo and worldwide expansion

Over the last decade, Brembo has been looking with great awareness to the emerging markets. In 2001, Brembo broadened its horizons and entered into the growing Chinese market in a joint venture with Yuejin Motor Group and in order to create the Nanjing Yuejin Automotive Brake System Company for the production of braking system for cars and commercial vehicles. Few years later, Brembo started its second production facilities in China.

In 2005, Brembo and Simest, a commercial bank that promotes the internationalization of Italian companies, signed an agreement to establish a new company in China. Brembo China, the joint venture participated by Brembo and Simest, specialized in the manufacturing and distribution of braking systems for the OEMs market. The new production plant was located in the Beijing area and supplied the main European and Asian car manufacturers who have production plants in Far East. In the same year, Brembo created KBX Motorbike Products to develop the Indian market. KBX was a joint venture between Brembo and Bosch Indian

subsidiary, Kalyani Brakes, for the production and commercialization of motorcycle braking systems.

Few years later, in 2008, Brembo inaugurated a new plant in India for the production of braking systems for motorcycles and scooters, and launched a new brand ByBre (an abbreviation of "By Brembo") dedicated to braking systems for scooters and small/mid-engine size for the BRIC markets and other countries in South East Asia.

In 2009, Brembo and Donghua Automotive Industrial Co., a member of the SAIC group – one of China's leading manufacturers of automobiles and commercial vehicles – signed a preliminary agreement for the purchase of cast iron foundry in order to build a new integrated industrial hub in Nanjing (Brembo Nanjing Foundry). The acquisition, completed in 2010, consolidated the Brembo Group's foothold in China by contributing to the creation of an integrated production facilities in Nanjing, complete with foundry and tooling machinery for brake calipers and discs for automobiles and commercial vehicles. The plant is capable of offering braking systems to the Chinese market that meet Brembo's standards for performance, style and comfort.

On 25th April 2012 Brembo officially opened its new manufacturing facilities in Nanjing. All stages of the production value chain, from the raw materials acceptance to the shipment of finished products, have been integrated into the new center. The plants employ about eight hundreds people and are able to produce about six million brake discs per year, for the most promising market in Asia. This new full-integrated facility represents the commitment of Brembo to meet the request of international customers and offer a complete range of products.

Regarding Europe, Brembo invests in Poland, where the third foundry of the group was opened in Dabrowa Gornicza in order to optimize the production cycle of the disc manufacturing plant. Operations of Brembo in Eastern Europe were further consolidated in 2010 with an investment in the Czech Republic for a new automobile braking system plant. This footstep brought the company into the mid-premium segment, working with clients such as Land Rover, BMW, GM and Audi.

5.5 Carbon ceramic technology

As innovation leader, Brembo has always been at cutting edge in using ground-breaking materials to continuously improve the performance and durability of its products. The carbon ceramic technology has been used formerly in braking systems for aerospace applications but thanks to the improvement of the expertise it has being adopted also in braking systems for racing and premium car segment, since it offers better performance in terms of weight and comfort. To develop the best products and to keep its role as innovator, Brembo sets up a joint venture with Daimler for the development and production of carbon ceramic brake discs. Daimler subsequently withdrew from the joint venture, while Brembo continued with SGL Group, with which it constituted an equal joint venture dedicated to the production of carbon ceramic brake discs, namely Brembo SGL Carbon Ceramic Brakes (BSCCB).

BSCCB's mission is to develop and manufacture braking systems in carbon ceramic material for the automotive markets. The medium term goal of the company, which is actively engaged in the exploration of innovative materials, is to develop a new generation of carbon ceramic material brake discs suitable for large-scale applications. Brembo SGL Carbon Ceramic Brakes employs approximately 350 persons in its two facilities, located at Stezzano (BG), in the Kilometro Rosso Science and Technology Park, and at Meitingen in Germany. BSCCB's customer includes prestigious automotive brands, such as Aston Martin, Audi, Bentley, Bugatti, Ferrari, Lamborghini and Porsche.

5.6 Brembo Group

Brembo and its affiliates, part of Brembo group, design, produce and offers high performance braking systems, clutches, seats, harnesses for both automotive and motorcycle markets. Brembo is head of the group and it owns several brands.

Brembo Racing represents Brembo in the racing market and sets apart the products oriented toward competition sector. Brembo Racing offers a complete range of products dedicated to racing and designed to provide maximum performance in the most extreme conditions. Brembo

Racing products are used by teams in the most important championship, such as Formula 1, NASCAR, Moto GP, Superbike, etc.

AP represents a brand of excellence in the global market of braking systems for cars. AP constantly pursues the goal of realizing an aftermarket product that is superior in quality and performance, taking advantage of its vast experience and success in the field of competitive sport.

AP Racing is a primary brand in the racing market of brake and clutch. AP Racing products represent the technological state of the art and are designed, manufactured and assembled for the world's most important Formula 1, GT, and Rally teams.

Marchesini is a top brand in the design and production of light alloy wheels for racing motorcycles.

Sabelt is engaged in the passive safety equipment market. The brand encompasses components and accessories for the automotive industry, including seat and seat belts, footwear and restraint systems for infants.

ByBre is a brand entirely dedicated to braking systems for small-to-mid engine size scooters and motorcycles for the emerging markets.

Breco is a brand for the aftermarket sales of discs and drums. Breco products are designed and produced to satisfy the strictest specifications required by major vehicle manufacturers and to obtain the most severe international certifications, in fact Breco products are certified as original or equivalent to the original product.

5.7 Intellectual property in Brembo

Brembo is strongly committed in research and development of innovative technical solutions and new material, which results in a range of excellent products that must be accurately protected. Brembo recognizes the strategic role of R&D and considers intellectual property as a key-element for achieving its strategy. The creation and the proper managing of intellectual

property assets are fundamental in company's strategy; therefore, there is an internal office dedicated to the development of company's intellectual property portfolio.

Brembo Intellectual Property office is a central unit that acts for the entire group. Brembo Intellectual Property office manages the entire company's portfolio, which includes a multifaceted set of intellectual property rights, such as trademarks, patent for invention, design patent, etc.

Brembo Intellectual Property office performs numerous activities, which comprise:

- support R&D department by performing prior-art search, freedom-to-operate search and patentability study, assess the opportunity to file a patent for a new invention and manage the whole patent application and prosecution process;
- manage the trademark portfolio by registering new trademark and expanding the protection of existing trademarks into emerging countries;
- monitor competitors' patent activity to report new remarkable patent applications to research and technicians and, in case, present an opposition procedure after patent grants;
- collaborate with legal counsels to draft license agreement and the contractual condition related to intellectual property rights;
- provide a technical support in case of patent infringement as well as for trademark or products counterfeiting;
- define and carry out the patenting policy for Brembo group;
- control the costs of intellectual property portfolio and define the budget.

5.7.1 Intellectual property strategy

Brembo has a strong commitment to research and development that sets the company apart as a leading name in its industry and as a supplier of state-of-the-art braking systems designed and produced specifically for high-quality automakers and racing teams. As a high-tech company and innovation leader, Brembo protects its products firstly with patents for invention.

In fact, the core of intellectual property portfolio is made up of patents. Using patents Brembo protects all the innovative technical features included in its brake disc, calipers and all other products.

Brembo pays also an extraordinary attention to the aesthetical look of its products. For example, Brembo Carbon Ceramic braking system was awarded with "Compasso d'Oro". Established in 1954, Compasso d'Oro Award is appointed by the Italian Association for the Industrial Design and represents the oldest and most influential industrial design award. Moreover, Brembo is very popular between the racing-enthusiastic for the design of its caliper, typically red-painted. According to this, Brembo must protect also the design of its products by using industrial design rights.

Brembo is recognized as a high-quality brand and to defend its product against imitators and counterfeiters, Brembo registered its trademarks and those of its subsidiaries almost in every country. For these reasons, Brembo adopts all the available intellectual property rights to protect the valuable intellectual property included in its products (e.g. technical innovation, design and brand value).

6. Patent portfolio assessment of Brembo's competitors

6.1 Chapter outline

Patent indicators described in the preceding chapters are now applied to patent portfolio of Brembo and three selected competitors. This chapter describes all the steps performed to carry out the analysis. First, patent indicators are examined one by one, then, they are combined to study the patent portfolio on the company level and provide a comprehensive overview about competitive environment.

6.2 Goals

The patent intelligence process is carried out on patent portfolio of Brembo and its main competitors, aiming to have an insight of their patenting strategy, to provide an overview of their technological focus as well as to indicate the marketing strategy for patented inventions.

6.3 Data sources

The collection was developed using FamPat, a commercial patent database that provides coverage of patent publications from the principal authorities (e.g. EPO, WIPO, USPTO, JPO, etc.). In FamPat, patents are grouped in invention-based families and enriched with full-text database. A single-family record combines together all publication stages of the family. The use of patent content on FamPat ensures a globally comprehensive collection. The documents included in the data set are patent applications and granted patents from the main industrialized countries. Utility models and design patents have been excluded from the data set.

6.4 Collection creation

The definition of the collection is the first step of the process. The investigated companies are: AKEBONO, BREMBO, CONTINENTAL TEVES and KNORR BREMSE.

In order to evaluate the authentic patent portfolio of the selected firms, only the patents currently assigned to these companies are considered. A patent filed by Akebono and sold to XYZ will not be included in Akebono's portfolio; on the other hand, a patent filed by ABC and bought by Brembo will be comprised in Brembo's portfolio. Moreover, all the subsidiaries entities of these companies have been included in the search. For instance, AP Racing is a UK-based company controlled by Brembo and its patents are comprised in Brembo's portfolio.

It was adopted a timespan slightly longer than the duration of a patent (i.e. 20 years) to include patents which, even their protection is expired, are frequently cited by later patents. Therefore, the earliest priority date has been set from 1/1/1990 to present. Older patents can lead to biased results, due to earlier patenting strategy and can encompass out-of-date technological field or obsolete inventions. Nevertheless, a too-short timespan would exclude those important patents that still represent fundamentals milestones for the technology.

While Brembo and Akebono produce mainly braking system for commercial vehicles, Continental supplies several automotive components (e.g. powertrain, chassis components, sensors, etc.) and Knorr Bremse manufactures braking systems also for mass transit and long-distance rail networks. Since the latter companies design a wide range of products, which are not strictly related to commercial vehicle braking systems, the search was restricted using few general keywords. The combination of the words "Brake(s)" or "Braking" and "Disc(s)" or "Disk(s)" was searched in the main patent fields (i.e. title, abstract and claims). These keywords guarantee that the patents found are somehow related with brake disc.

6.5 Conventions and definitions

6.5.1 Patent counting

FamPat database is structured around patent families, which encompass all the patent documents related to specific invention. All counts of records refer to patent families and not to individual patent documents, providing a more accurate measure of the inventive activity from a

company. For example, a patent application filed at EPO, USPTO and JPO for a single invention is counted in aggregate as one.

6.5.2 Timeline and dates

As each patent family potentially contains numerous patent documents, which have different priority and publication date, the earliest known priority date is used (unless otherwise noted). The earliest priority date provides the most accurate indication of the time of inventive activity.

6.6 Company overview

6.6.1 Akebono Brake

Akebono is a Japanese brake manufacturer and its brakes are used in vehicles, motorcycles, rail cars and industrial machineries. Automotive brakes are at the core of Akebono's business, main products include disc brakes and drum brakes as well as friction material brake pads and drum brake linings. Akebono controls roughly 40% of Japan's market share for automotive disc brake pads on OEM basis and approximately 18% of the worldwide OEM disc brake pad market. Akebono net sales in financial year 2011 were 209.6 billion ¥ and the employees as of March 2012 were approximately 7˙800.

6.6.2 Brembo

Brembo is an Italian manufacturing company and an acknowledged innovation leader in the field of automotive disc brake technology. The company supplies high performance braking systems to the premier manufacturers of automobiles, motorcycles and commercial vehicles worldwide. Further, Brembo offers a comprehensive range of products dedicated exclusively to racing and created for teams participating in the most important motor sports competitions. For more than 30 years, Brembo braking systems have helped the most successful racing teams to win the world's most prestigious races. Sales turnover of Brembo in 2011 amounted to 1˙254.5 million € and the group has a workforce of about 7˙000 employees.

6.6.3 Continental Teves

In 1998, Continental Corporation acquired ITT Industries, a US-based company, the core of which was Alfred Teves, a historic brand of the brake industry. Thanks to the acquisition, Continental Teves becomes a brake system supplier to the automotive industry and is known as a developer and manufacturer of hydraulic and electronic brakes. Continental Teves is part of Continental Corporation, which ranks among the top 5 automotive suppliers worldwide. Continental develops and produces a wide range of functional parts and components for the automotive industry, including safety and stability systems, components for powertrains, chassis, tires and instrumentation. Chassis & Safety Division of Continental Corporation, which includes electronic brake system and brake caliper production, had sales for 6˙510.8 millions € in 2011 and employs about 32˙000 persons.

6.6.4 Knorr-Bremse

Knorr-Bremse is a German company, leading manufacturer of braking systems for rail and commercial vehicles. Company's sales are divided half-and-half between rail vehicle and commercial vehicle. Knorr-Bremse Commercial Vehicle Systems offers braking systems for trucks and buses. Additional product areas include torsional vibration dampers for diesel engines as well as powertrain systems. In 2011, Knorr-Bremse Group had consolidate sales for 4˙240.8 million € and employed a total of 20˙050 persons.

6.7 Portfolio composition

The data set retrieved with the search has been carefully analyzed to sort the documents according their kind (i.e. patent for invention, utility model and design patent). Table 6.1 shows the composition of the companies' patent portfolio through the classification of the different intellectual property rights.

Table 6.1 - Companies' patent portfolio

Portfolio composition	Assignee			
	AKEBONO	BREMBO	CONTINENTAL TEVES	KNORR BREMSE
Records founded	651	236	453	642
Incorrect results[5]		1		2
Total design patent[6]	4	11	0	1
Total utility model	42	3	1	31
- Utility model DE	1		1	30
- Utility model JP	41	1		
- Utility model CN		1		1
- Utility model ES		1		
- Utility model FR				
Total patent	605	221	452	608

Brembo stands out for its eleven design patents, proving its attention to protect also the appearance of its products and not just their technical features. Since Brembo produces calipers and brake discs for racing and premium vehicles, the product design plays an essential role and must be carefully protected. Akebono recently began to pursue the same strategy, thus it has registered four design patents. On the contrary, Continental Teves and Knorr Bremse do not protect the products design, likely because they focus more on commercial and industrial sectors than Brembo and Akebono. Utility models have requirements less strict than for patents and protect minor technology improvements. Akebono and Knorr Bremse own, respectively, 42 and 31 utility models, filed mainly in their home country. Traditionally, companies from Germany and Japan pay great attention to their intellectual property and use widely also utility models.

[5] Incorrect results are those patents that do not belong to the company's portfolio but have been included in the result set for a misleading name in their assignee field.

[6] FamPat covers only design patents filed in United States. It has not been possible to retrieve industrial design patent filed in others countries.

6.8 Indicators for patent intelligence

Once the data have been gathered and the patent collection has been defined, the information was processed to develop the following indicators for patent intelligence.

6.8.1 Distribution by priority year

Companies' portfolios have been plotted over time showing the priority application filed per year (Fig. 6.1). A simple patent count would be poorly informative but the dynamic development of priority applications over time provides a quick overview of the company's portfolio. The two last years on the chart are incomplete due to the publication lag (patents are published 18 months after priority filing).

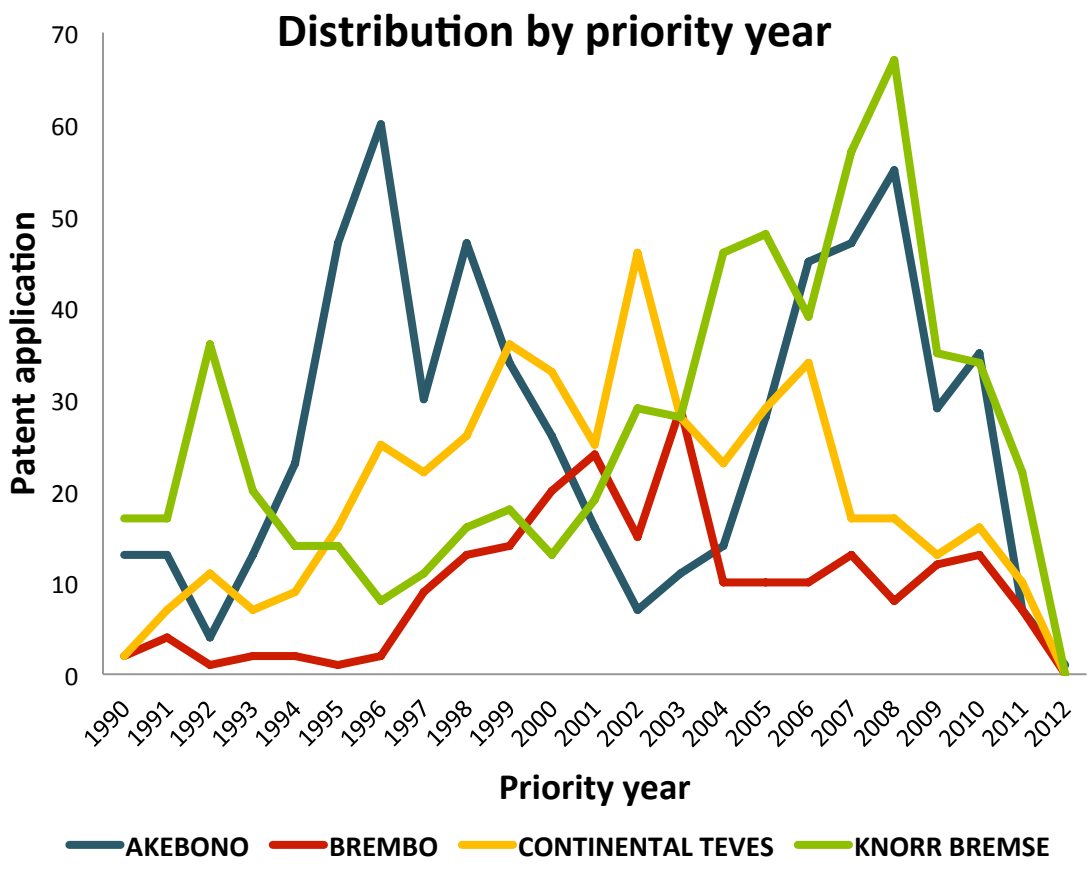

Fig. 6.1 - Distribution of patent application by priority year

In 90's Akebono filed much more patents than others players, with a maximum peak of 60 priority filings in 1996. Since then, Akebono drastically reduced the number of new filings until

2002, when it has gradually started to increase patenting activity again. In 2009 and 2010, Akebono decreased significantly its number of filings cutting almost by half, moving from 55 to 29 new applications.

Brembo had very lower patent activity in the 90's and started to file a considerable number of patents only in 1997, hence it shows an upward trend reaching highest filing activity in 2003. Afterwards, Brembo had a steady number of priority filings with an average of about ten priority filings per year. The last three years shows a slightly growth and there is an upward outlook for Brembo's patenting activity in the coming years.

In the last two decades Continental Teves presented a regular and convincing patent activity. It filed on average about twenty patents per year before 2001, and then patenting activity started to increase. In 2002, Continental Teves filed 46 patents, overcoming all others competitors. However, in the last years, Continental Teves' activity exhibits a small decrease.

Knorr Bremse ranks first in terms of patent applications. In spite of an ordinary number of filings in the 90's, far behind compared to Akebono, in 2000 it began to gradually increase the priority applications. In 2008, Knorr Bremse reached the highest number of priority filings (i.e. 67 patents) among all the considered companies. Nevertheless, it occurred a substantial drop of priority applications in 2009 and 2010.

6.8.2 Portfolio maturity

The previous analysis successfully shows the trend of patenting activity but does not provide a clear indication of the maturity of the overall portfolio. Portfolio maturity indicates the age-distribution within each company's portfolio, giving an additional measure of the patenting efforts over time.

First, patent family age is calculated referring to earliest priority date, and then patent families are grouped in four categories of 5-years timespan plus one for the expired patents. The bar chart of Fig. 6.2 shows the percentage of each category within the portfolio. The latest category (i.e. patent age from 0 to 5 years) is incomplete due to the publication lag.

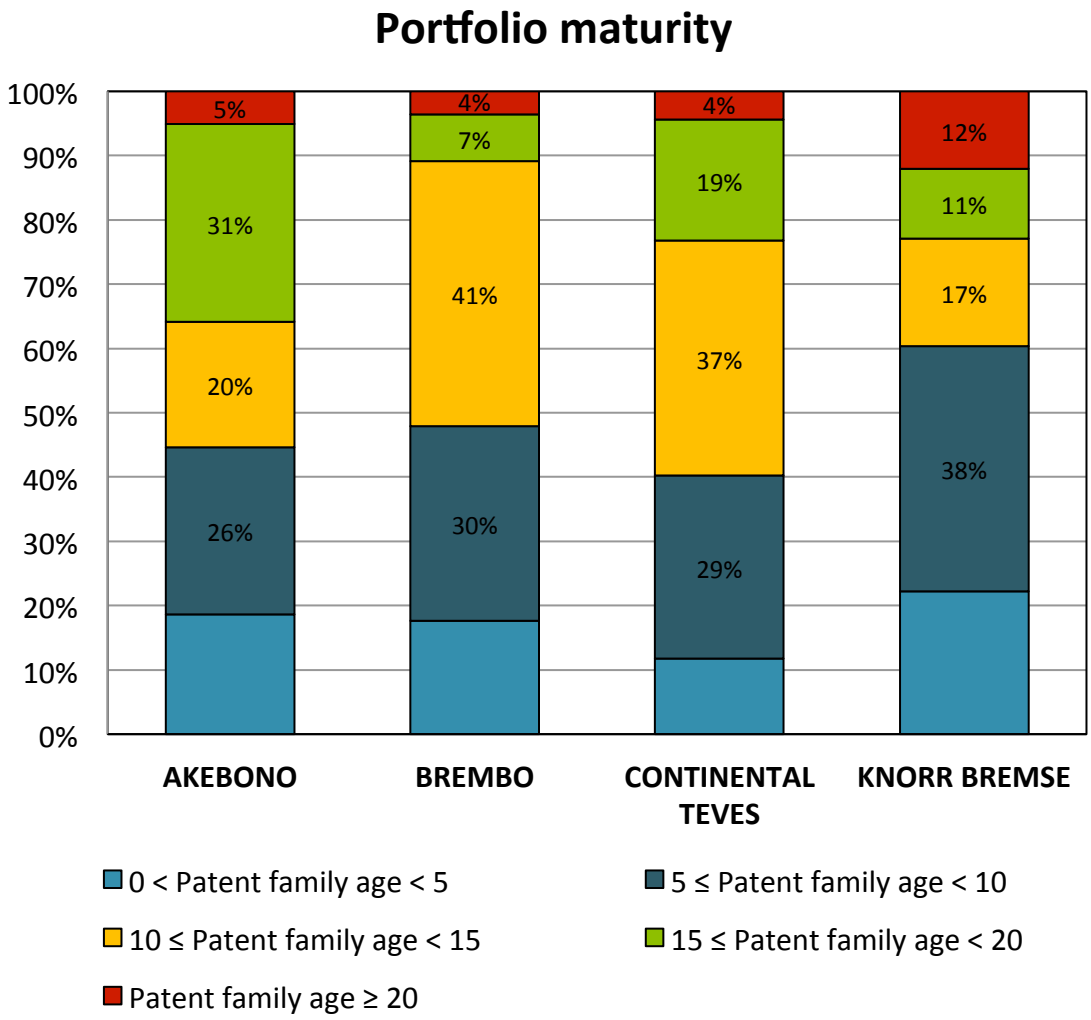

Fig. 6.2 - Patent portfolio maturity

As noted in the previous analysis, Akebono was particularly active between 1993 and 1998; in fact; about thirty percent of its portfolio is between 15 and 20 years old. In the same period, Brembo filed few patents, only 7% of patent families has more than 5 years to expiry. However, in the following 5-year period Brembo increased dramatically its patent activity, filings about 40% of its patent between 1998 and 2003. Even Continental Teves was especially active in this period.

Nonetheless Knorr Bremse filed several patent applications also before 2003, it experience an extraordinary patent-boom from 2003 to 2008, when it applied for about forty percent of its patent portfolio.

6.8.3 Distribution by priority country

Priority country (i.e. country of first filing) provides an indication on the patenting strategy pursued by the applicant. Typically, priority filings are made in the corporation's headquarter country and consequently extended abroad whether the patentee still has expectation regarding the utility and marketability of the invention.

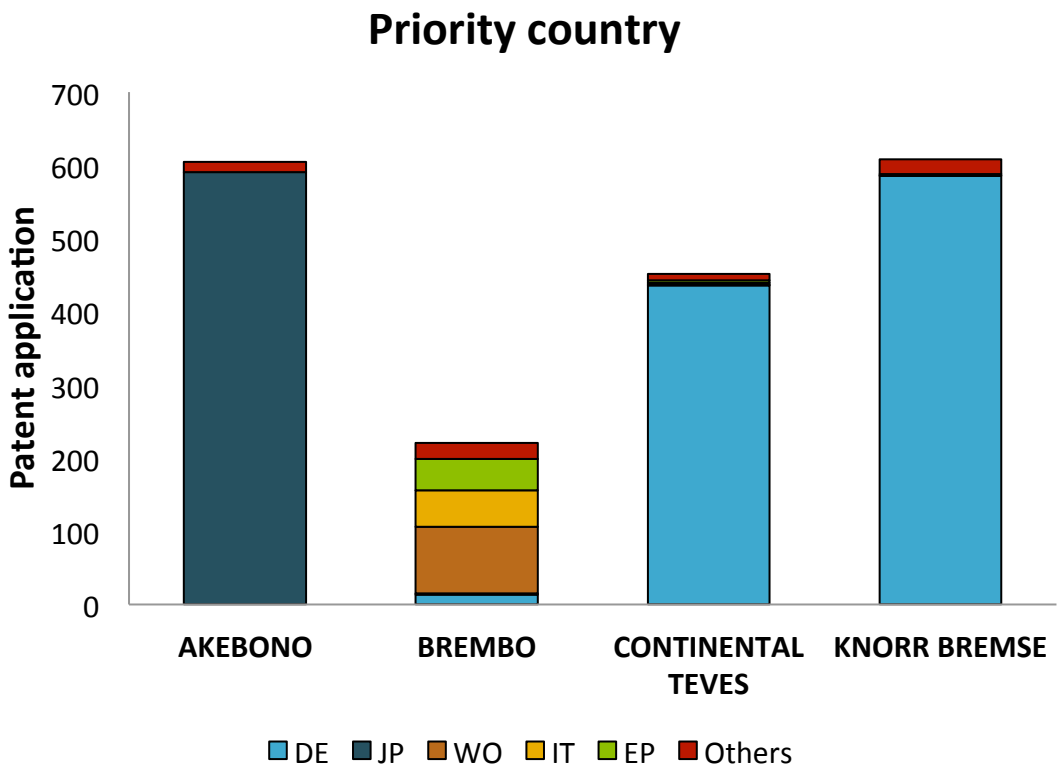

Fig. 6.3 - Distribution of patent applications by priority country

Akebono, Continental Teves and Knorr Bremse follow precisely this strategy. 95% of their application originates from a priority application filed in their respective home country (i.e. Japan for Akebono; Germany for Continental Teves and Knorr Bremse). Instead, Brembo pursued different patenting strategy. Before 2008, Brembo typically filed a European or PCT patent application to obtain protection abroad. Nowadays, Brembo firstly file an Italian application thanks to which it receives an international search report. Two patents originated from Japan because Brembo collaborated with Honda to develop market-specific products and thirteen patents have a German priority because have been bought from Daimler.

6.8.4 Distribution by publication country

A single patent only provides protection within the country of the authority that granted the patent. This means that inventors must file applications for the patent in each country where they foresee to produce or sell the patent-protected product. Thus, geographic filings strategy reflects company's market strategy. The chart 6.4 shows the number of filings by companies for the principal countries.

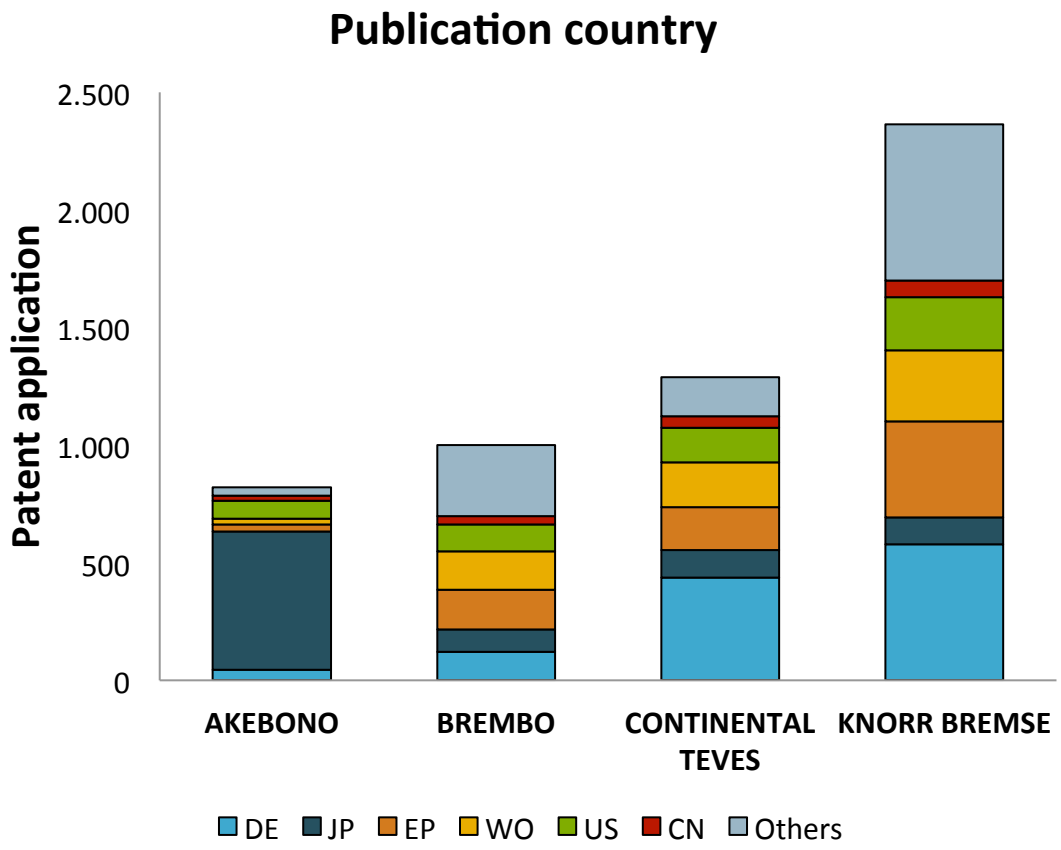

Fig. 6.4 - Distribution of patent application by publication country

Akebono portfolio is heavily biased towards Japan, only about one tenth of Akebono's patents are filed also in United States, while very few are European or PCT applications. This geographical filings strategy confirms the focus on the domestic market, while protection abroad is requested just for key-inventions.

Brembo, Continental Teves and Knorr Bremse share a comparable geographical strategy. Despite Knorr Bremse owns more patents than Continental Teves and Brembo, the share of patent applications are distributed across the countries in the same way. The ratio of European, PCT and United States applications are similar for the portfolio of each firm.

Continental Teves and Knorr Bremse are German-based companies and they file a significant number of domestic applications, thus they have a relevant share of German filings. Brembo, whose headquarter is located in Italy, has 59 Italian patent applications.

Considering individual patent documents (e.g. patent applications for the same invention filed at EPO and USPTO count as two, even if they are included in the same patent family), Brembo overtakes Akebono. Despite Akebono owns 605 priority filings in Japan, it has required protection abroad for just few of them. Surprisingly, Brembo, which possesses far fewer priority applications, has about one thousand individual patents, proving that Brembo's portfolio has a broader market scope than Akebono. Continental Teves and Knorr Bremse have more individual patents than Brembo, even if the average patent family size is lower than the Italian company. The average patent family size is calculated as the number of individual documents divided by the number of patent family. It can be used as a proxy for the international scope of the portfolio.

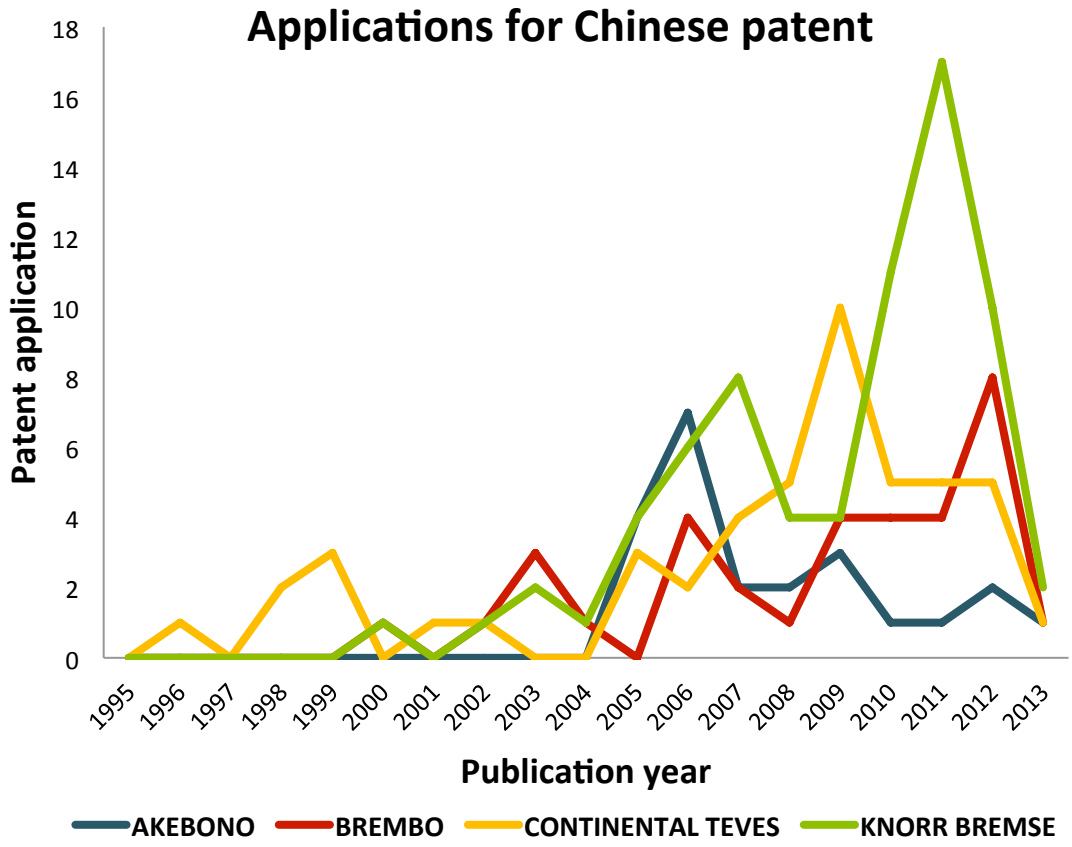

Fig. 6.5 - Distribution of applications for Chinese patent by publication year

Even though Chinese patent applications still cover a small share of the companies' portfolio, all of them have started to file patent at the State Intellectual Property Office of P.R.C. from the beginning of 21st century. The upward trend presented in Fig. 6.5 proves the increasing interest of Chinese market. As a matter of fact, companies have settled new plants in China in order to supply efficiently both local and international automakers.

6.8.5 Trilateral and quadrilateral filings

A patent filed in Europe, United States and Japan is defined as trilateral filing, and it turns in quadrilateral when it is filed also in China. Since trilateral and quadrilateral patents require significant investment, just the main inventions are filed in several foreign territories. For this reason, trilateral and quadrilateral filings are an additional measure of the geographical scope of a patent.

The pie charts (Fig 6.6) show the share of trilateral and quadrilateral patent families in the company's portfolio. It must be noted that quadrilateral are filed in Europe, United States, Japan and China, thus are implicitly trilateral filings. Anyway, the trilateral filings in the chart comprise only those patents filed exclusively in Europe, United States and Japan to avoid overlap and double-counting.

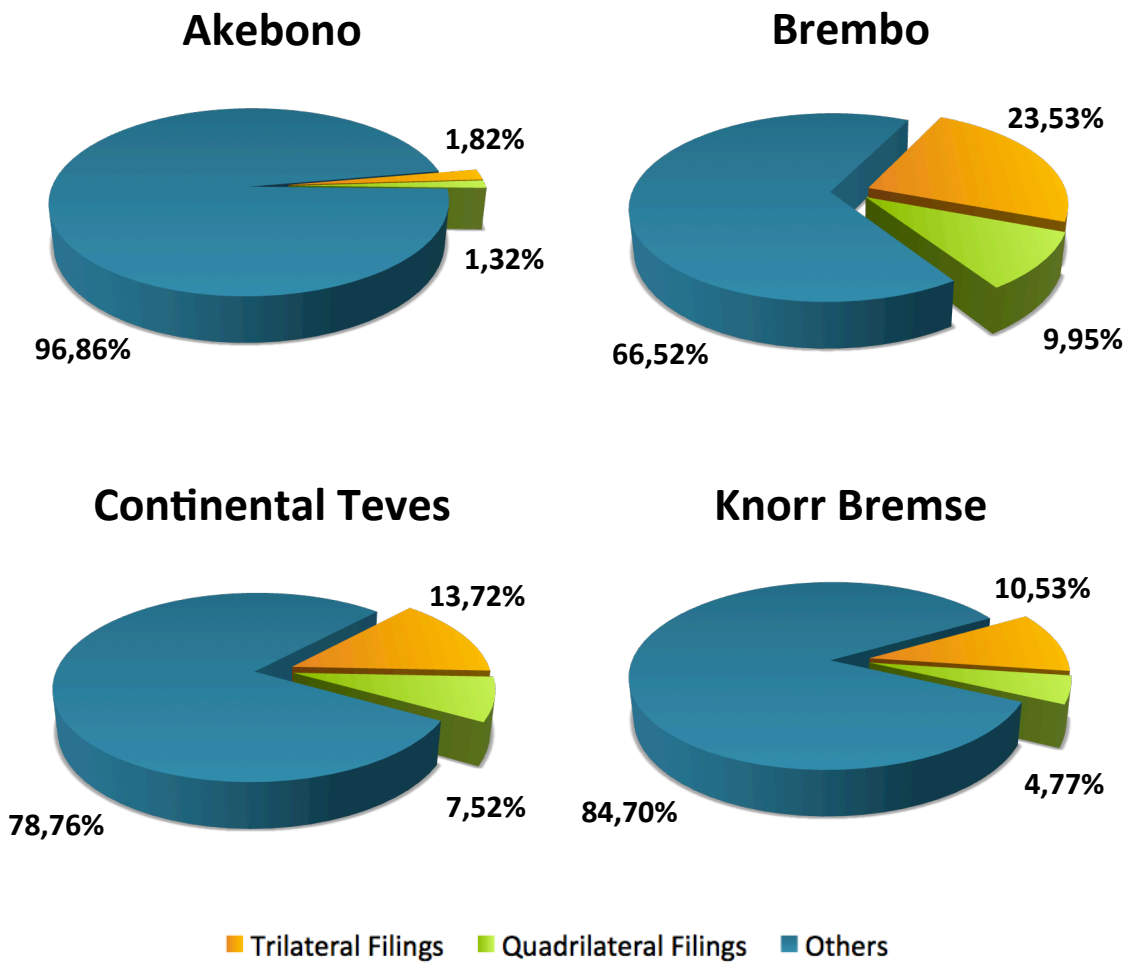

Fig. 6.6 - Trilateral and quadrilateral filings

Despite of its many domestic filings, Akebono has very few trilateral and quadrilateral patent families, indicating a low interest in the international market. Conversely, Brembo protects about a quarter of its inventions in Europe, United States and Japan and it looks for protection also in China, achieving the highest share of quadrilateral filings in the analysis. The outstanding international scope of Brembo's patents demonstrates its worldwide marketing

strategy. Continental Teves has 96 trilateral and 34 quadrilateral patent families and it ranks first in absolute terms. However, due to the high number of applications, the ratio of trilateral and quadrilateral filings is lower than Brembo. Since Continental Teves and Knorr Bremse own a comparable number of trilateral and quadrilateral patents, their portfolios have a similar international scope.

6.8.6 Top IPC Groups

Patent authorities sort patents in a classification scheme on the basis of technical contents. International Patent Classification (IPC) is a worldwide-adopted scheme and helps to identify the key-technology of a patent set.

The chart 6.8 shows the top ten IPC groups of the entire collection. F16D-065 is by far the first IPC group in terms of patent applications and it contains patents related to “Parts or details of brakes”. F16D-055 is the second IPC group with just a half of patent application of the first and it covers “Brakes with substantially-radial braking surfaces pressed together in axial direction, e.g. disc brakes”. The high concentration of patents in these two IPC groups confirms that the majority of patent in the collection are relevant for the scope of analysis. Remaining IPC groups contains fewer patents in comparison with the first and second groups.

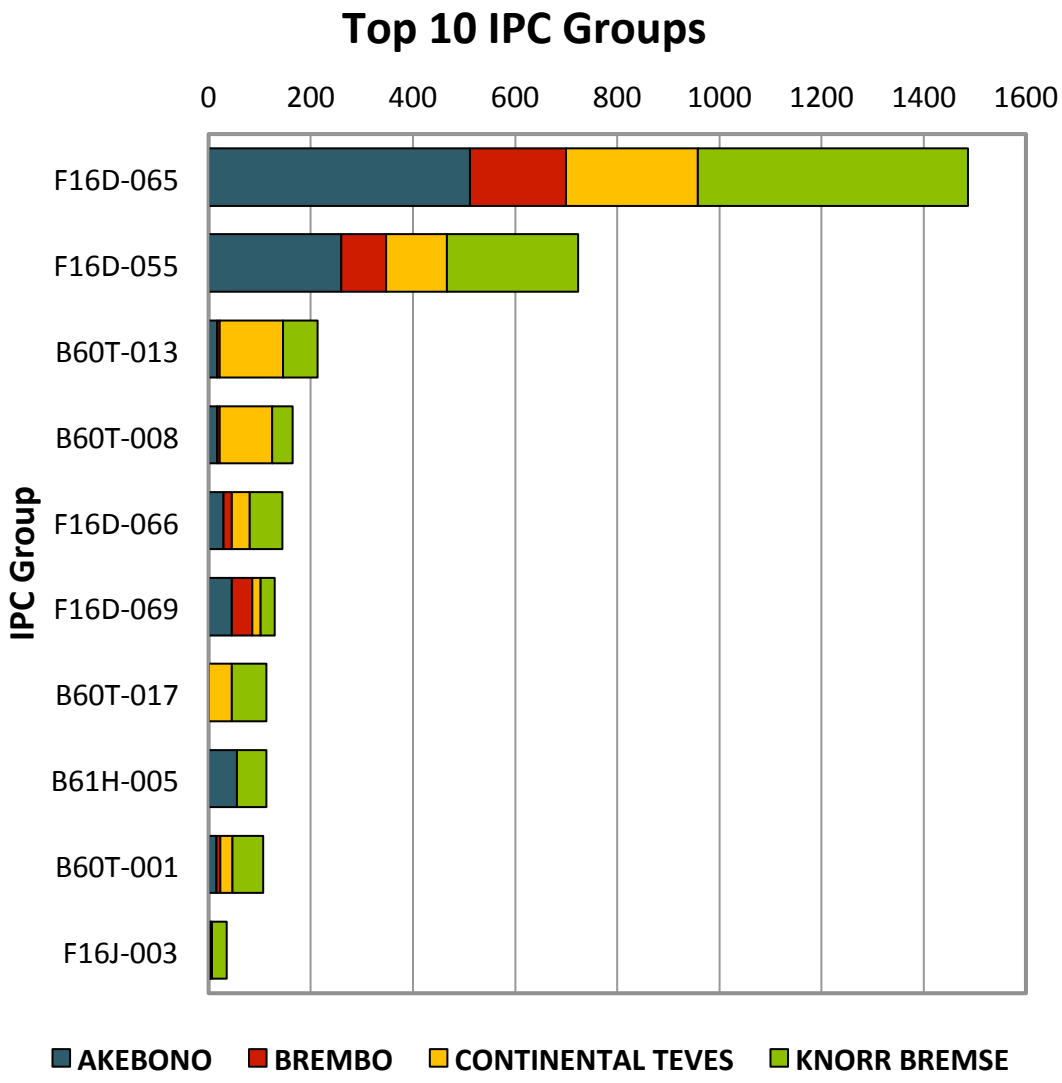

Fig. 6.7 - Top 10 IPC Groups

6.8.7 Distribution of IPC Groups

The bar chart of Fig. 6.8 clearly shows the "hot areas" within the collection, however it is hard to distinguish the technology focus of a specific firm. Therefore, the relevance of principal IPC groups within company's portfolio (Fig. 6.9) can provide a better insight of its technological focus.

Akebono and Brembo share almost the same distribution of IPC groups in their respective portfolios, indicating a very similar technology focus. F16D-065 is the first technology class for both of them and it covers more than half of their portfolio. A quarter of their patents are also

placed under F16D-055, which ranks as second IPC group. Continental Teves shows a more differentiated portfolio. F16D-065 is still the first group but with a lower share over the total, afterward F16D-055, B60T-013 and B60T-008 follows with roughly the same weight. Knorr Bremse's technology focus places between Brembo and Continental Teves. The main groups is F16D-065, even if it has slightly less than half of the portfolio; it follows F16D-055 with twenty-one percent and the remaining is allocated in different classes. B60T-013 and F16D-066 have about five percent impact on the portfolio and others groups weight for twenty-one percent.

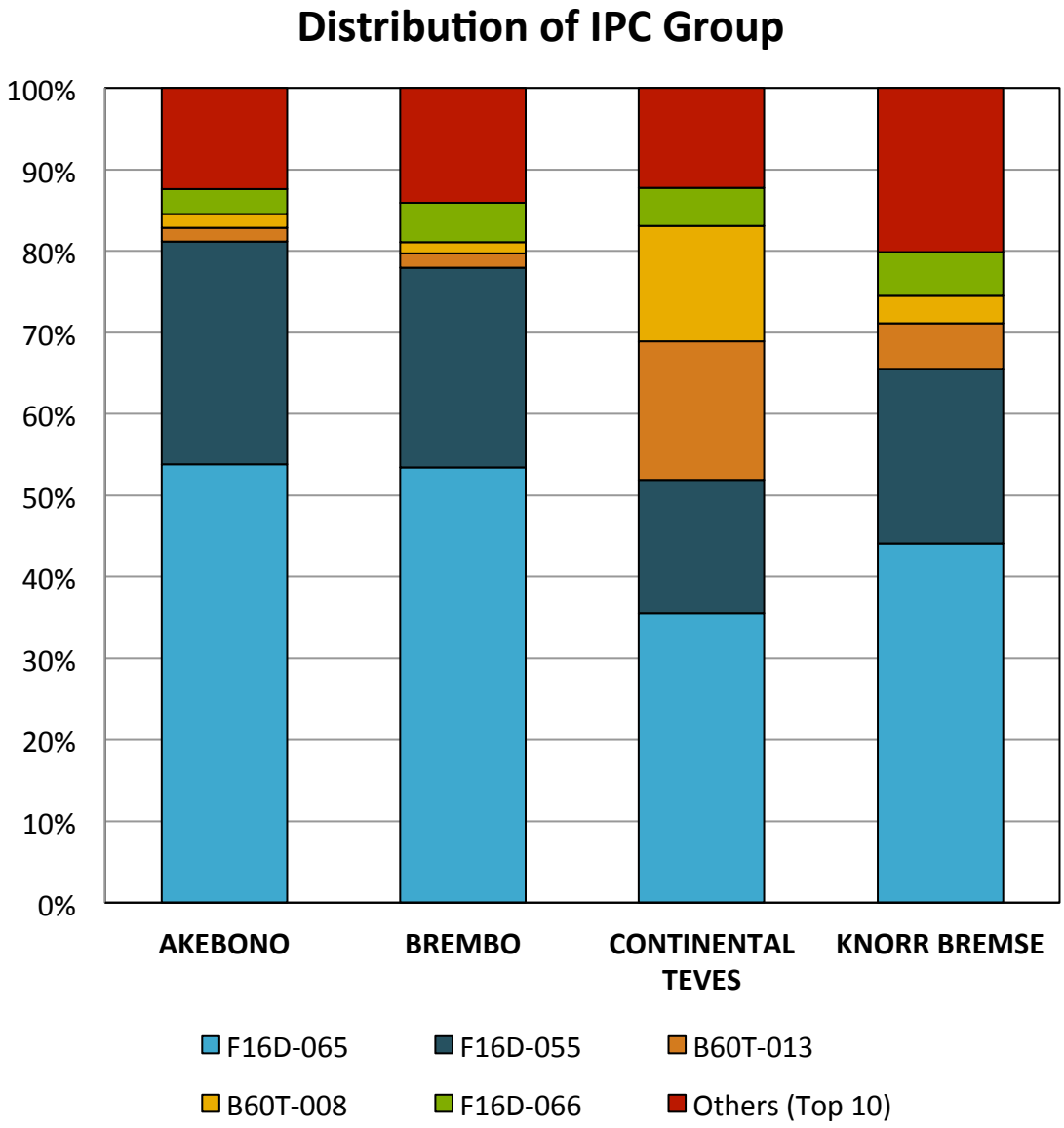

Fig. 6.8 - Distribution of IPC Group by company

6.8.8 Cluster of patents

The full text of patent documents has been analyzed through a text-mining tool aiming to offer an overall view of the technology clusters in which the companies operate. ThemeScape®, a commercial software used to perform the analysis, creates content maps from a full text patent database. A content map is a visual representation of the collection of patent documents organized by thematic content. First, an algorithm analyzes the text (i.e. title and abstract) of each patent family record and creates clusters for the main concepts. Then, common conceptual terms are displayed in a topological two-dimension map, with peaks representing a concentration of documents and showing the relative relationship of one record to another. Including natural language improves the quality of the resulting analysis and gives a landscape map more informative than one created with first-level patent data only. These maps offers a bird's-eye view of the entire landscape and help to easily identify common themes within the data set by looking at the concept cluster. A concept map of the entire collection was created using ThemeScape®, then patents were grouped according to the assignees and highlighted with different colure (Fig. 6.10).

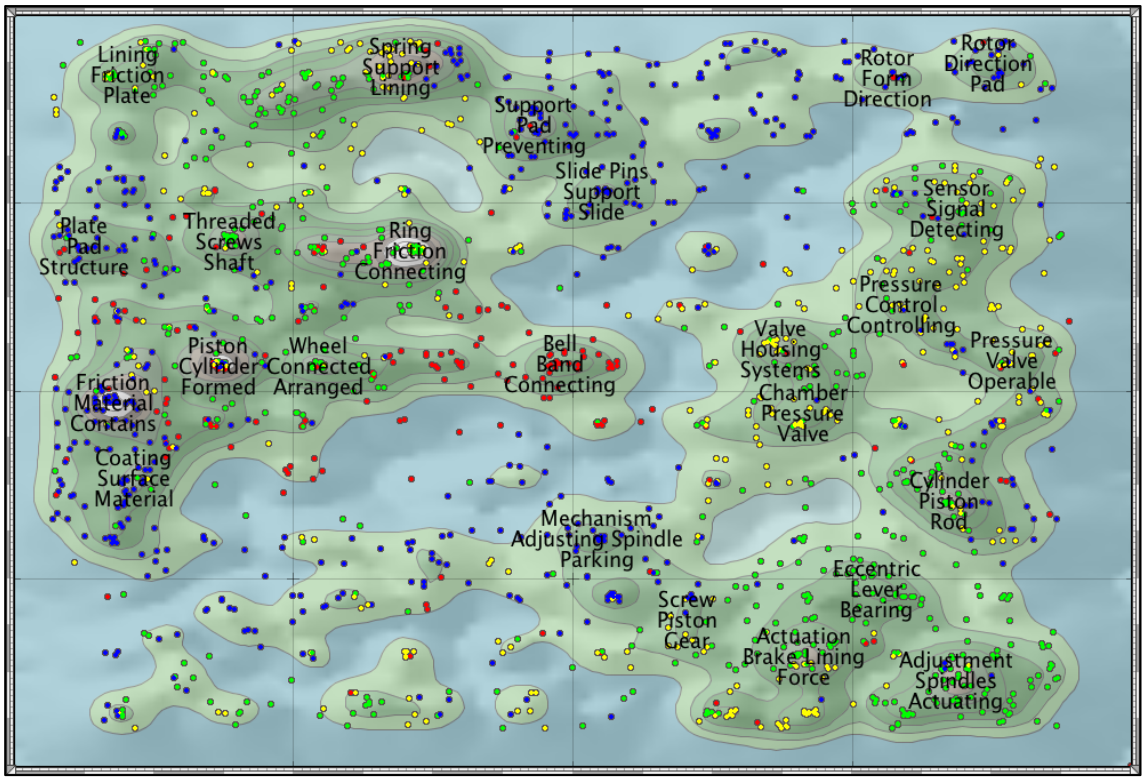

Fig. 6.9 - ThemeScape® Map

As expected, there is a majority of green and blue dots, which represent Knorr Bremse and Akebono, because they own a huge number of patents of the collection. Akebono's patents are concentrated principally in two main areas, the first concerns friction and coating surface materials, the second relates to device for supporting brake pad. The principal concepts for Brembo are the brake disc band and the connection between the bell and the brake disc. Continental Teves has many patents covering sensors, while Knorr Bremse prevails in the terms concerning industrial applications.

6.8.9 Distribution of citations and self-citing ratio

Citations information can be used to determine how much related are the technologies that companies are working on.

The table 6.2 shows how citations are distributed between the considered companies (only citations originated and directed to selected companies are taken into account). For example,

considering the first row of the second column, it can be seen that three percent of citations made by Akebono refer to Brembo.

Table 6.2 - Distribution of citations between the considered companies

Assignee A cites B					
		B			
		Akebono	Brembo	Continental Teves	Knorr Bremse
A	Akebono	79%	3%	12%	6%
	Brembo	9%	52%	25%	15%
	Continental Teves	4%	3%	84%	9%
	Knorr Bremse	3%	4%	26%	67%

All companies are related each other, since they works in the same technological field. The citations made by a company to the competitors are equally distributed. Continental Teves remarkably receive more citations than average. An interesting outcome of the citations analysis is that all companies have at least half of citations refer to themselves, which is considerably high. Self-cites ratio ranges from 52% of Brembo to 84% of Continental Teves (it must be considered that Brembo has a smaller patent portfolio than other competitors, resulting in a lower number of citations). This indicates that all the firms continue to improve upon earlier inventions and to file additional applications.

6.8.10 Distribution of legal status

Legal status data relates to legal events in the lifetime of patent (e.g. grant, abandon, expiry, etc.). Legal status analysis provides an indication on the number of rights effectively enforceable and on patents abandoned, expired or revoked. Further, legal data makes possible to measure the company's interest in the prosecution stage of applications.

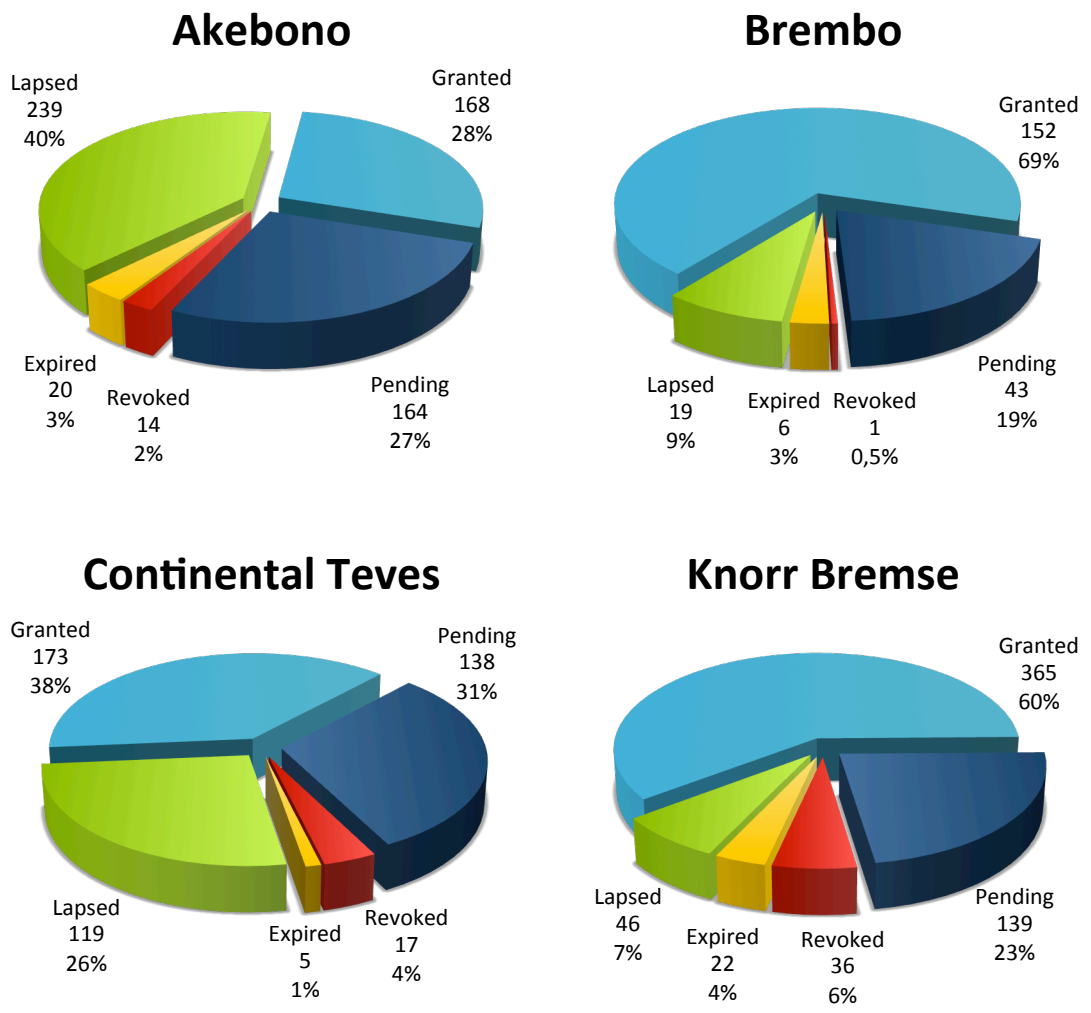

Fig. 6.10 - Distribution of patent applications by legal status

In terms of grant success rate Brembo ranks first among the companies analyzed. It has the highest share of granted patents (69 %), demonstrating a strong commitment in obtaining grant for the application filed. Knorr Bremse and Continental Teves follow with respectively 59% and 38%. Knorr Bremse achieves an excellent result, especially because it has 365 granted patents in comparison with an average of 215 (i.e. mean of entire collection). Continental Teves has a lower grant ratio, however a relevant share of its application is still pending (31%). Legal status analysis also shows that just 28% of Akebono's patents have been granted. Although Akebono is one of the most active firms as number of patent applications, it shows a poor interest in the prosecution stage (about 40% of Akebono applications are lapsed). In absolute terms, Akebono

and Brembo have almost the same number of granted patents (Akebono, 168; Brembo, 152), though Akebono's portfolio includes 605 patents applications and Brembo just 221. The share of lapsed patents is considerably lower for others firms; Continental Teves has 26%, Brembo 8% and Knorr Bremse 7%. The remaining part of companies' portfolio are expired patents, those that have been filed 20 years ago or more and their protection is now terminated. On average companies have about 5% of expired patents in the studied portfolio, ranging from 7% of Akebono and Knorr Bremse to 3% of Brembo. The last minor share of company's portfolio is made by revoke patents, which do not meet the patentability requirements and have been revoked by the examiner.

6.9 Patent portfolio on the company level

Analysis of patent indicators gives a number of strategic information but does not provide a comprehensive overview about competitive environment. Since each indicator is based on a specific field (e.g. priority date, publication country, IPC group, etc.), traditional patent indicators fail to deliver an overall framework. As already explained in the previous chapters, company's patent portfolio can be valued according two factors: patent activity and patent quality. Patent activity is certainly an important factor to describe the innovative power of company, but is not solely decisive. Patent quality is even more significant. Technology leaders usually distinguish themselves not only by possessing the highest patent activity but also the highest patent quality. Astonishingly, companies with a high patent quality but lower patent activity prove to be more successful on the market than those that focus on mass instead of class (Fabry, Ernst, Langholz, & Köster, 2006).

Patent quality index takes into account four core characteristics of company's patent portfolio: 1) the strength is measured by the share of granted patents; 2) the diversity and number of IPC groups in firm's patent applications are used as a proxy of technological quality; 3) the share of triadic patents indicates the international scope of the portfolio and 4) citation frequency provides an objective hint of economic quality.

The patenting behaviors of the studied companies are displayed in the diagram of Fig. 6.11. The value on the horizontal axis is the patent activity (in absolute term the scale goes from 0 to 943 patent applications), while the value on the vertical axis refers to the patent quality index.

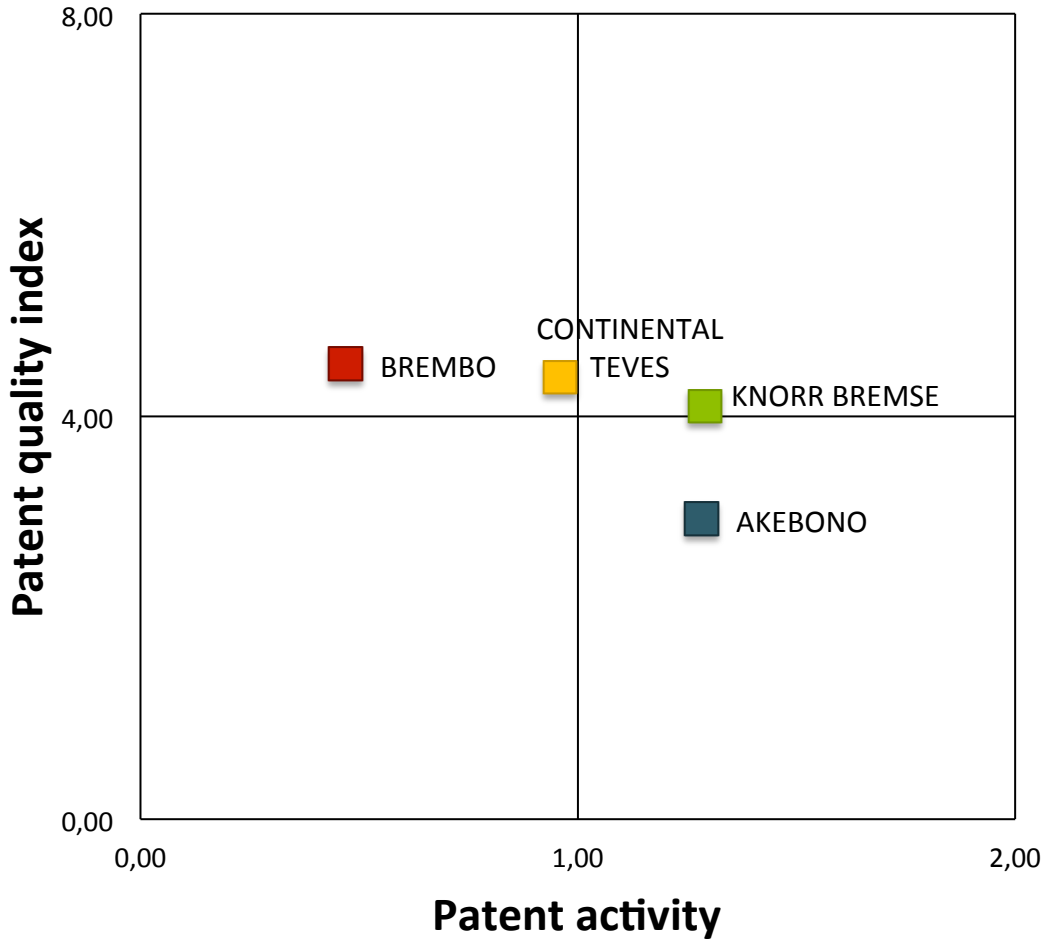

Fig. 6.11 - Identification of patenting strategies in patent portfolio

Brembo has the highest patent quality index and is located in the upper, left hand quadrant of the chart. It is classified as "selective patentees of high-quality patents". Typically, smaller companies are located here, which do not file many patents but are technology leader. These companies should be carefully monitored. Continental Teves places itself not far from Brembo. Despite of a slightly lower patent quality, Continental Teves has a patent activity very close to the collection average. Increasing its number of filings, Continental Teves could reach the upper, right hand quadrant, where are located "Active patentees of high-quality patents". Even

if it is located on a borderline position, Knorr Bremse find itself in this quadrant. Its patent quality index is barely above the average but its patent activity is the highest within the sample. Akebono shares with Knorr Bremse the role of patenting leaders, but the quality of its patents does not seem as valuable as Knorr Bremse. Akebono locates in the lower quadrant and is categorized as an active patentee of low-quality patents.

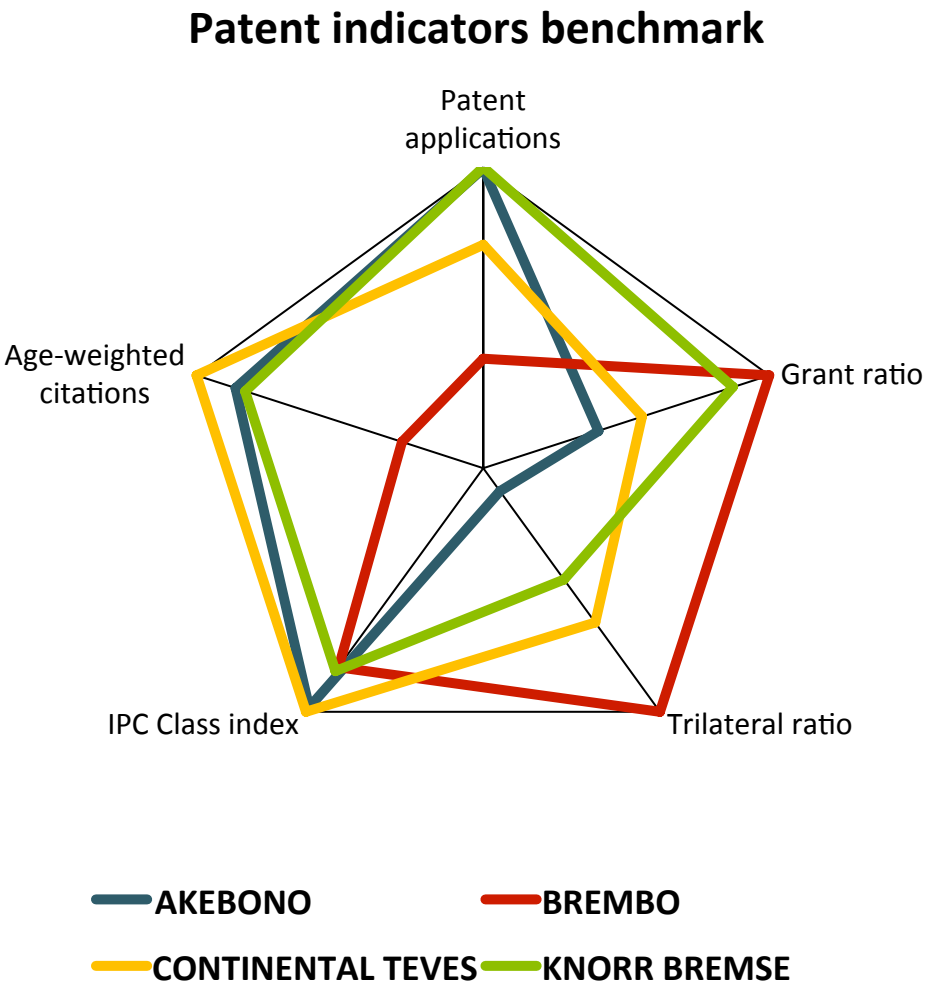

Fig. 6.12 - Benchmark of patent indicators

In order to examine in depth the patent quality index, the underlying indicators are considered. A particularly convenient presentation of all the parameters used in the competitive benchmarking is the radar chart, as it allows to simultaneous presentation of the five parameters. Fig. 6.12 illustrates the parameters that describe the patent portfolio of the selected companies

(i.e. patent activity and the four indicators of patent quality). The highest value of each parameter is set at 100% and all other values are related to it. Every curve in the radar chart connects the five parameters of the company. Ideally, a perfect pentagon on the 100% curve would result for a company that would be leading in all five indicators.

The chart points out clearly the strengths and the weaknesses of each company. Akebono obtains an excellent score in patent applications and technology scope, placing close to the best company, and it also achieves a pretty good citation frequency. Nevertheless, it has the worst trilateral ratio and share of granted patents. Opposed to Akebono, Brembo has the worst patent applications and age weighted citations but it is the best in terms of trilateral and grant ratio. These first-class variables explain the reason why Brembo has the highest patent quality. Continent Teves, whose patent quality is just less than Brembo has reasonable patent activity, share of granted patents and triadic filings. Further, Continental Teves is the best of class for age-weighted citations and IPC Class index. Finally, Knorr Bremse prevails for the number of applications filed and, generally, obtains good scores – even if not the best - in every patent indicator.

7. Patent intelligence and market assessment

7.1 Chapter outline

A complete patent analysis should not be solely based on technological considerations but it should also take market perspective into account. Integrating the patent analysis and market data can help to develop effective indicators. This chapter proposes two analyses to relate patents and market data. The first combines sales data and patent application providing an indicator to verify the trade-off between patent efforts and market results. The latter tries to evaluate the technological condition of a market in order to identify potential opportunity and future outcome using patents as source of information.

7.2 Integrating patent intelligence and market information

A proper patent indicator to be used for the assessment of correlation between marketing and patenting strategy is the geographic distribution of filings. Since patents prove the intention of the assignee to produce or market an invention in a specific country, geographical filing strategy give hints about potential markets for the patent-protected product. Ultimately, combining market data and geographical filing strategy allows verifying the adequacy of patenting strategy in comparison with market requirements.

To maintain the advantage of having objective data for the comparison, company's net sales are considered as market measure. More specifically, sales are accounted by region in order to be easily compared with geographical patenting strategy. Relative values are calculated as 1) sales by region on company's net sales[7] and 2) patents filed in an area on all firm's patent applications.[8] Then, the two relative values are plotted in a scatter chart (conventionally, sales are indicated in abscissa and patent in ordinate) and represent company's position.

[7] Sales data refers to financial year 2011.
[8] All patents of company's selected portfolio excluded PCT applications.

Unlike traditional chart, a remarkable firm's positioning is neither achieved only by having high values, nor simply improving patent applications or sales, but must be a right balance between regional sales and patent protection. For example, having a strong concentration on a regional market (80% of company's sales in Asia) with a poor patent protection (20% of patents portfolio filed in Asia) would result in a critical risk. In fact, the company would be under-protected in the considered area. Vice versa, high patent coverage with low regional sales would mean over-protection of the area, which could signify inappropriate costs. The correct strategic positioning of the company is along the main diagonal, presenting approximately the same value for sales and patent protection indicator. This guarantees the right alignment between market requirements and efforts in patent strategy within a geographical area. The chart is particularly convenient because allows achieving both internal and external analysis: firstly, it is possible to verify the competitive positioning of company according to its marketing and geographical patenting strategy, secondly, it offers a comparison with its industry competitors. However, a limitation of the analysis must be recognized. Since it relies only on quantitative data, it does not consider specific patenting strategy. For instance, a strong patenting activity in an area with modest sales could be justified by the presence of a competitor. Hence, over-protection is convenient to avoid the strengthening of its position.

The charts of Fig 7.1, 7.2 and 7.3 show the positioning of studied industry player in the three main macro-areas (Europe, Asia and America).

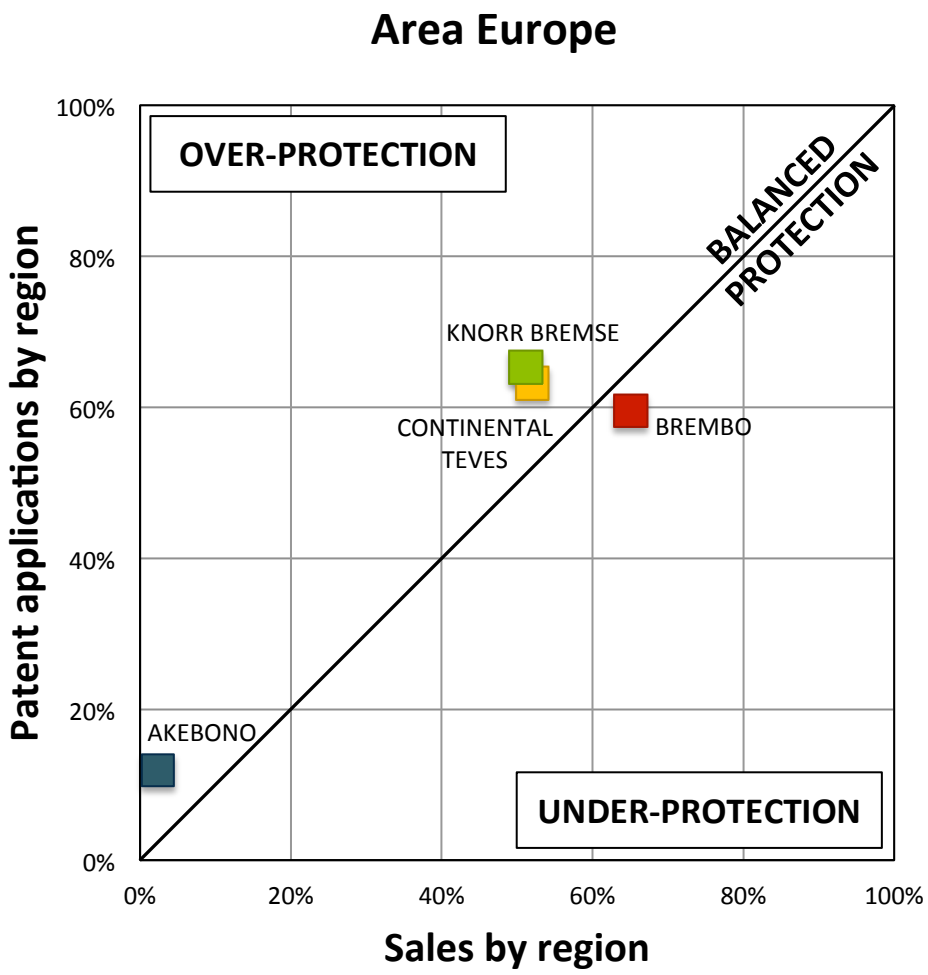

Fig. 7.1 - Correlation between sales and patent applications in Europe

Europe is the first market for Brembo, Knorr Bremse and Continental Teves. As shown on the chart, about 60% of sales are addressed to European area. The three companies have a balanced protection, having a share of patent application and sales similar. Akebono is a Japan-based company and European market accounts for 2% ca., however Akebono has a considerable share of patent applications filed in Europe.

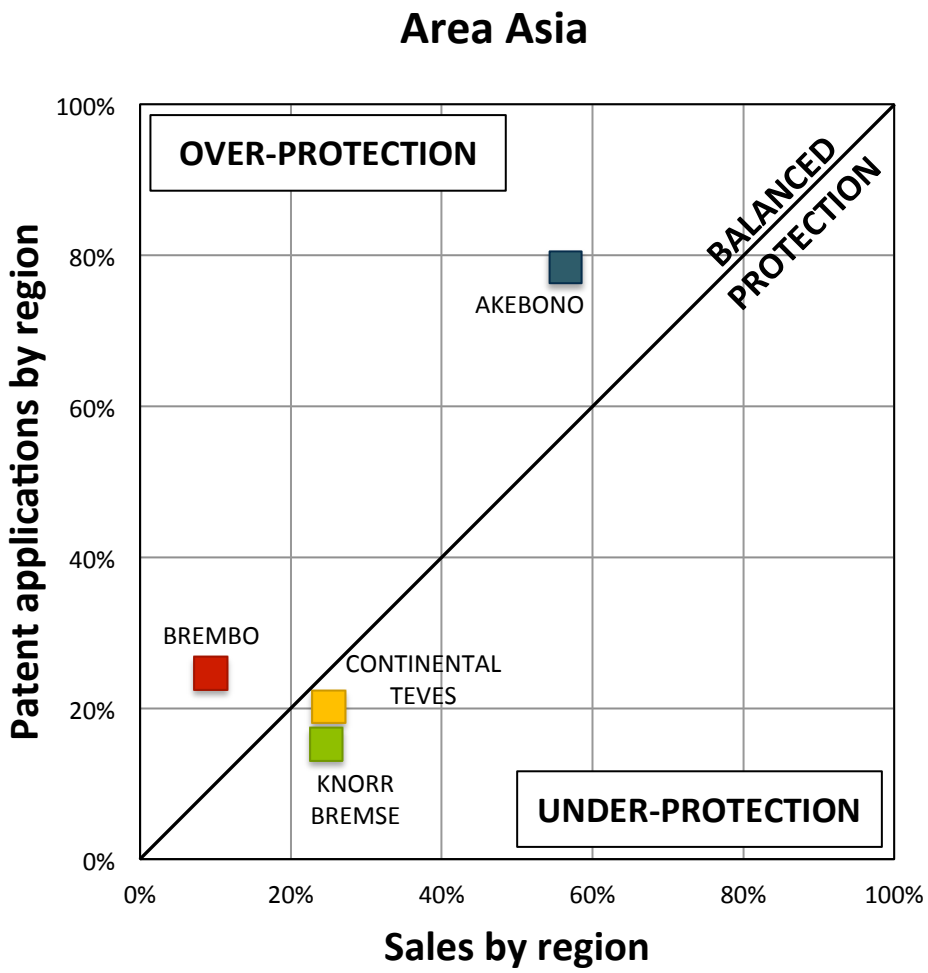

Fig. 7.2 - Correlation between sales and patent applications in Asia

Akebono's filings are strongly oriented toward Asia. Firstly, Akebono is focused on the domestic market, as it can be seen from sales ratio; secondly, it undergoes on home-effect, since Akebono files many patent in Japan but it requires for protection abroad just in few cases. For Continental Teves and Knorr Bremse, Asia account approximately a quarter of total net sales. Continental Teves has about 20% of its patent portfolio in Asia, while Knorr Bremse is slightly under-protected (15%).

On the other hand, Brembo seems to be over-protected in Asia but there are two reasons related to patent strategy. One of Brembo's main competitors, Akebono, markets its products principally in Japan, therefore Brembo looks for protection in order to prevent counterfeiting

risk. Moreover, Brembo owns an integrated production facilities in China, therefore it apply for protection in the production country.

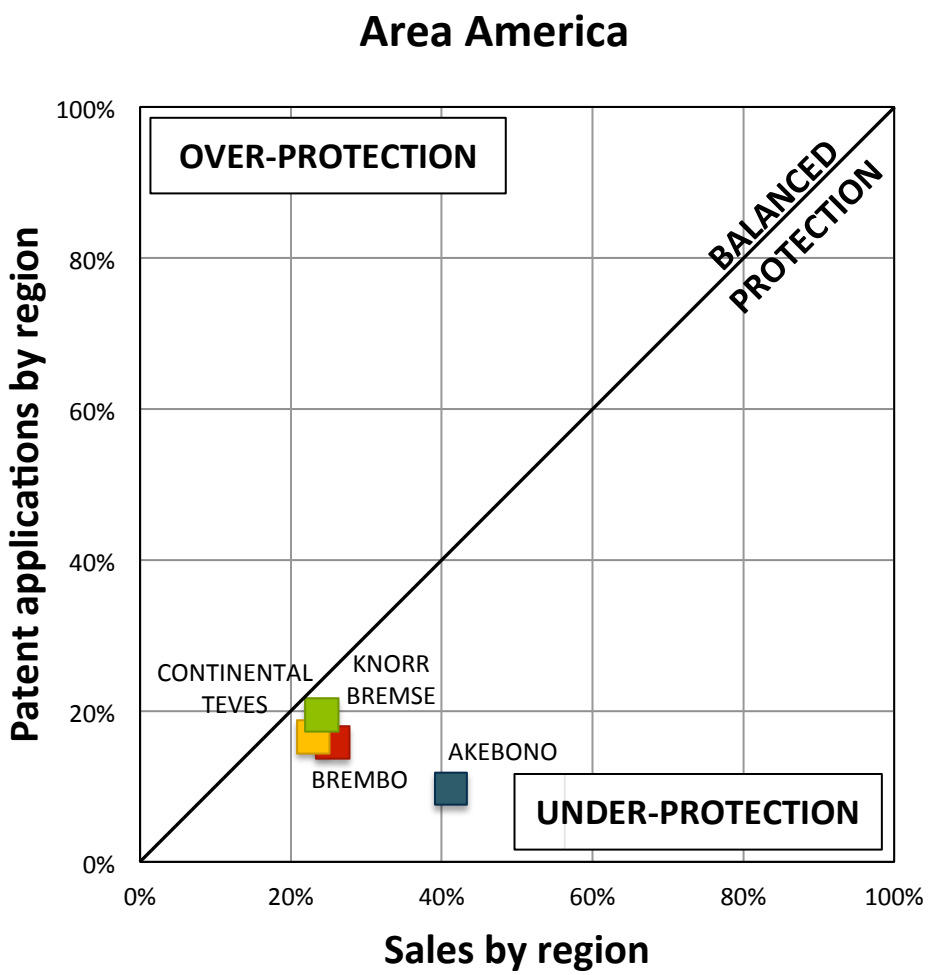

Fig. 7.3 - Correlation between sales and patent applications in America

Brembo, Knorr Bremse and Continental Teves have a similar balancing between patent protection and sales in America. Akebono is exposed to under-protection risk in America. Despite sales in America accounts forty percent for Akebono, it has only a ten percent of its entire portfolio protecting this region.

7.3 Market evaluation from a patent-perspective

Patent intelligence approach can be used also for assessing the technology condition of a market by studying its major player with a comprehensive set of patent indicators. Specifically, the situation of Chinese light vehicle market is evaluated by analyzing the patent portfolio of the biggest five automotive companies. First, an overview of Chinese market and its impact on international automotive industry is presented. Second, patent indicators, such as distribution of priority filings, kind of patent rights and geographical filing strategy, are used to assess the technical knowledge of local car manufacturers. Finally, it is proposed an outlook on the future development of market, the trends and the implications on international automotive companies.

7.3.1 An overview of light-vehicle Chinese market

Chinese robust growth, urbanization, low vehicle ownership rate and continuous highway expansion impact positively on internal automotive market and will support domestic's long-term vehicle demand. The estimates foresee an increase of the domestic vehicle park sustained by growing population and wealth. The overall motorization rate (measured as number of cars per 1˙000 inhabitants) will increase until 2025, with an expected compound annual growth rate around 10%, compared to a growth between 0,1% and 1,2% per annum in triadic markets (i.e. North America, Europe, Korea and Japan).

The growth of Chinese market impacts on international automotive industry by two major trends: 1) Chinese automotive market has become a key sales-volume contributor for most global OEMs groups and offers further growth opportunity, 2) Chinese companies start to play an important role in global markets (Roland Berger, 2012).

China's passenger cars market is booming and the trend is likely to continue for the coming years. After surpassing the U.S. in 2009, China has overtaken Europe in 2012 as sales of passenger vehicle, becoming the world's largest automotive market. Additionally, China's industry is expected to continue growing, reaching 33 million units by 2018 (Western Europe and U.S. market will be around 18 million units). Chinese market is a strategic growth

opportunity not just for local automakers but also for international automotive companies. While Europe's car market continues to shrink, the Chinese market is experiencing a strong expansion. Volkswagen exploited properly the Chinese market's opportunity; in 2012 the German-based company sold more cars in China than in all of Europe. In order to catch up with the fast growing vehicle market and to better supply local customers, international providers have moved to Asia and settled R&D centers and regional headquarters. International car manufacturers are extending their production capacity in China with numerous plants opening in the near future. In the next five years, about sixty percent of global production capacity will occur in China, slightly more than half of which will be controlled by Chinese OEMs.

On the other hand, Chinese automotive companies are increasing their volumes and starting to enter in global markets. According to the global sales of light vehicles in 2010, five Chinese OEMs had emerged to the top 20 car manufacturers worldwide. Chinese OEMs had invested massively to improve their competitiveness both at home and abroad. In addition, major Chinese OEMs announced market and production expansion to Europe. For example, Chery and Great Wall have established assembly operations in developing markets outside China and announced to open assembly plant in western countries (e.g. Italy, Egypt, etc.). China is ready to produce more cars than Europe in 2013 for the first time, hitting a landmark in the country's rise of automobile industry. According to the projections, car production in China in 2013 is likely to be tenfold than in 2000 – when its share of global auto manufacturing was just 3.5% as opposed to a likely 23.8% in 2013.

7.3.2 Analysis of patent portfolio

Despite the extraordinary growth of market size and production capacity of local OEMs, there are several concerns about quality and safety standards of Chinese vehicles. Generally, the requirements of Chinese market in terms of quality and technology are lower than international standards. Therefore, domestic manufacturers' vehicles are addressed to low or medium market segment, while the premium market is still dominated by international OEMs. Looking at the

technology of Chinese market from a patent-perspective reveals four main findings that support the underdevelopment of technology in Chinese automotive industry.

7.3.2.1 An unsustainable growth of patent applications

The patenting activity of the top five Chinese automotive companies in the past decade has been analyzed (Fig. 7.4). The considered Chinese OEMs are Chery, Geely, BYD Auto, FAW and Great Wall Motor. Just few years ago Chinese companies do not care at all about patenting activity. From 2006, the count of their filings has been growth surprisingly and it almost double year on year, showing an exceptional upward trend of number of filings in the last years. Data on 2011 and 2012 are incomplete due to the publication lag.

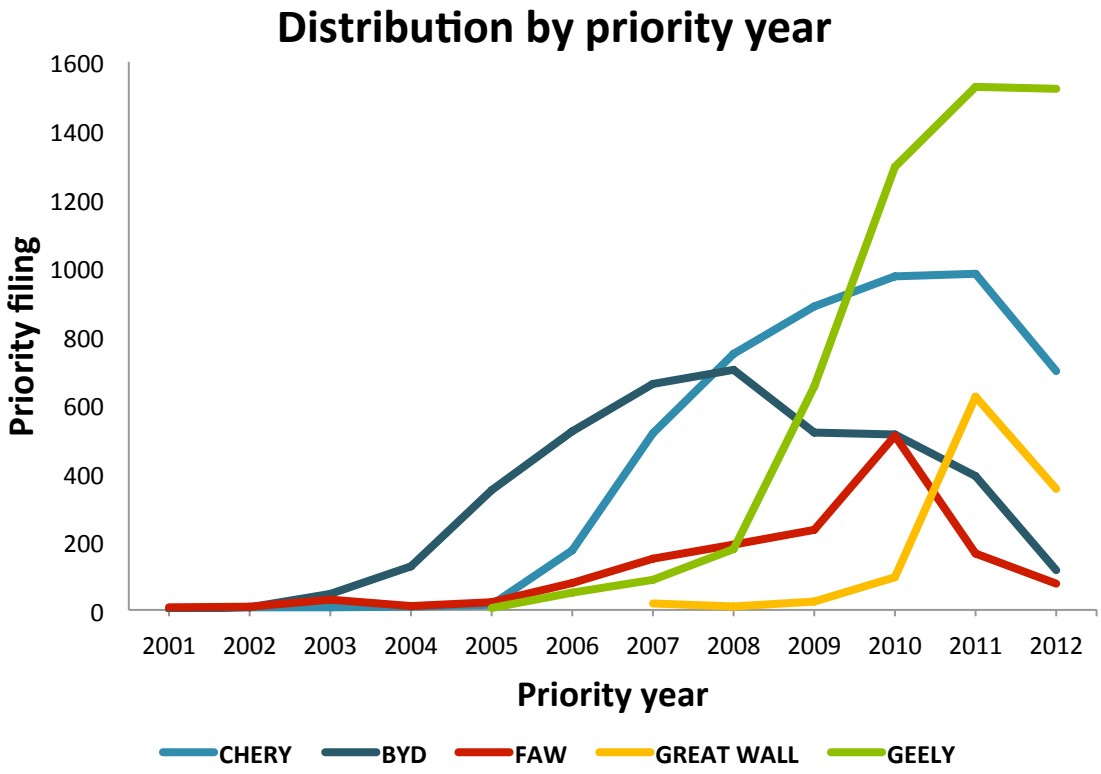

Fig. 7.4 - Distribution of patent applications by priority year

Nevertheless, the extraordinary growth of Chinese patent applications could be a misleading indication and could raise grounded concerns about the quality of Chinese patents. As illustrated in the previous chapter, China bursting patent policy is amplified by governmental system of incentives rather than really driven by innovation.

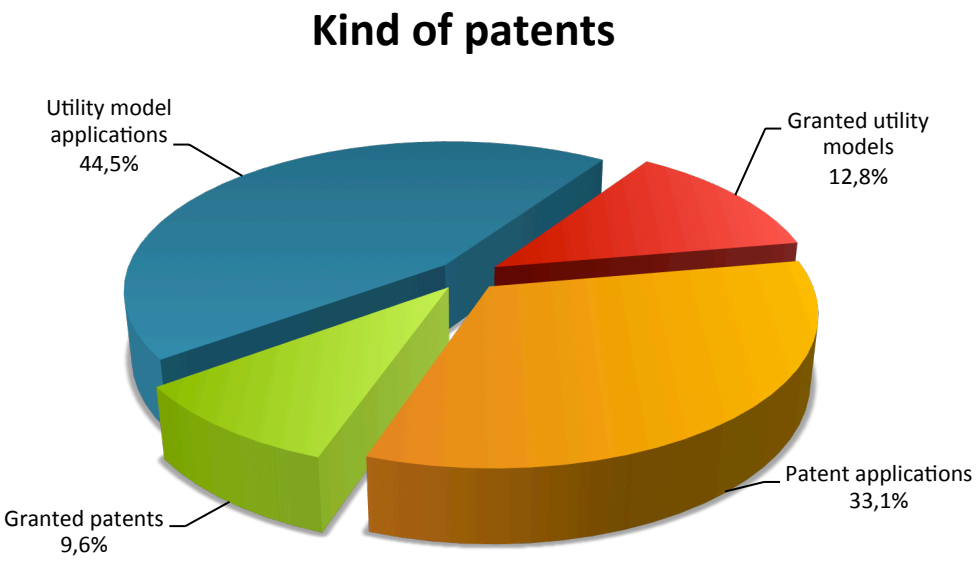

Fig. 7.5 - Distribution of patents by kind code

7.3.2.2 Utility models rather than patents for invention

Going deeper with the analysis of each company's patent portfolio comes to light that a considerable number of filings are for utility models, whose requirements for grant are lower than patents. Utility models protect any new solutions concerning the shape of a product, which is particularly fitted for practical use and they do not undergo a substantial examination, therefore utility models are not a recognized proof of technology progress as patents for invention.

7.3.2.3 Low share of granted patents

Furthermore, the patent quality is questioned also by the low share of granted patents of the companies' patent portfolio. On average, the grant success rate among the considered companies does not exceed ten percent and the applications for utility model weigh nearly half of the portfolio (Fig 7.5).

7.3.2.4 International scope

The international scope of patents, one of the indicator presented in the previous chapter, is an excellent proxy of patent quality. The rational behind this indicator is that applicants must file a patent in each country they expect to produce or sell the patent-protected products; so, wider is the geographical coverage of a patent, higher would be its value. The international scope of patents filed by Chinese automakers is incredibly low. Protection abroad is requested for less than 2% of domestic patent applications.

7.3.3 Outlook for Chinese brake system market

The patent portfolio of Chinese car manufacturers was examined in detail to evaluate the potential market penetration for international supplier of brake systems. The patent collection of the selected companies was restricted using the IPC Class related to brake already identified in portfolio benchmarking (Fig. 7.6). The outcome was a small number of results with a modest quality level. In fact, only 2% ca. of the portfolio concerns the brake system. Patents applications have been recently filed and approximately half are utility models, meaning that cover minor improvement oriented to cost-reduction and oversimplification rather than significant advance in technology. From a patent-perspective, Chinese car manufacturer are not developing brake technology internally and in future they might be customers of international suppliers once their requirements will meet the quality level of the offerers.

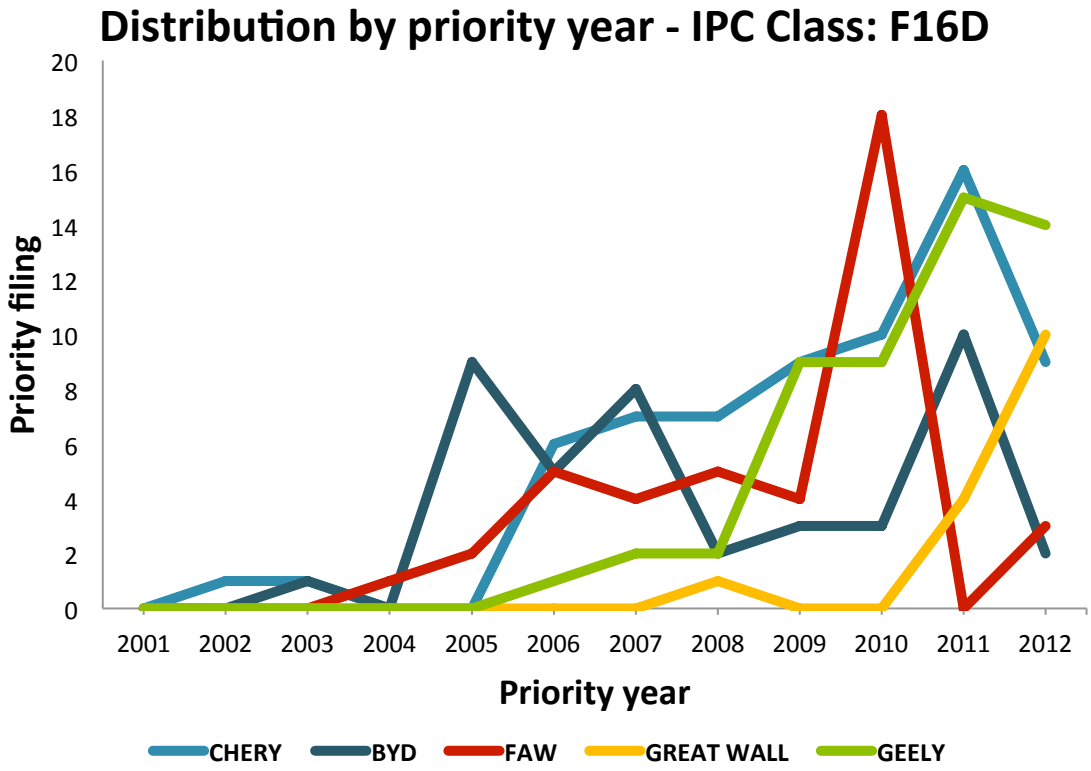

Fig. 7.6 - Distribution of patent applications by priority year - IPC Class: F16D

As others components suppliers, Brembo considers Chinese market as a valuable opportunity. Brembo already operates an integrated production facilities in China, which supply brake systems to the plants of international OEMs settled in China, including BMW, Daimler, Volkswagen, Iveco and MG. International car manufacturers have already planned extensive investments in China, opening new plants and localizing production of vehicles that today are imported from other countries. For this reason, Chinese automotive market size will further increase, turning out to be a golden opportunity for growth.

Despite a ten-year presence and activity in China, Brembo does not sell any product to local car manufacturer. The high-quality standards and the relative higher price of global suppliers usually do not meet the local demand, which ask for low-cost components. Local Chinese market is still underdeveloped for the quality level Brembo products, but the fast technological improvement could raise fast the level of Chinese premium car manufacturer to international standards. The demand of components of higher quality would offer a market opportunity to the

global components suppliers. Alternatively, Brembo could consider entering in the market with a technological breakthrough specifically developed for the local markets.

7.3.4 Key findings and implications for further research

The unsustainable growth of patent applications and the modest grant ratio, the amount of utility model on total filings and the protection requested only within the country's boundaries are the principal reasons to doubt about Chinese patent quality and, consequently, about technology level of Chinese automotive market.

The domestic Chinese car manufacturers are aware of their lack of technology and are trying to improve their product as fast as possible. In fact, local OEMs are establishing joint ventures with international automotive companies to enhance their product value and technology.

In conclusion, the result shows that Chinese car manufacturers are not yet ready for international automotive supplier, but the indigenous innovation policy and the technology transfer through JVs are quickly developing the technological environment. In the next years, the continuous improvement will take Chinese market to higher quality standards offering a valuable growth opportunity for international OEMs and components suppliers, nevertheless Chinese companies will acquire and develop their own technology and will set a tougher and competitive environment, raising pricing pressure for international companies also in their established markets.

The joined analysis of patent documents and market information completes technological considerations adding value from a business perspective. The integration of these two sources of information is useful to understand competitive positioning, growth opportunity and industry trend. Further research may be focus more carefully on a specific product and a limited geographic area. China is surely an interesting region, its market is bubbling and it develops at fast pace. Moreover, Chinese government had recently reviewed emission regulation and strongly promotes electric vehicle. These changes offer new opportunity for brake systems, which would be more coupled to engine and powertrain.

8. Conclusion

Patent intelligence is understood as a process, which comprises the collection and analysis of information disclosed in patent documents aiming to create and communicate knowledge about internal and external environments. Patent intelligence can be successfully used to measure technological position of a company, its strength and weakness both from technological and market point of view. Knowledge of competitors' patent portfolio enables companies benchmarking.

To perform patent intelligence process, a complete set of patent indicators has been developed. Patent indicators are based both on structured and unstructured patent data and addresses to different area of competences. Patent activity and portfolio maturity are calculated from the priority date and provide information on R&D efforts; patents issued by different national authorities reveal company's geographic distribution and provide hints on potential markets for the patent-protected products. Applicant and inventor fields reveal networks of collaborations, partnership between companies, universities and research centers as well as key-inventors in a certain technological field. Analysis of classification scheme allows identifying the core technologies of firm's patent portfolio and forecasting their evolution over time. Patent citations indicate fundamental technologies and help to identify key patents, suitable for licensing opportunities. Text mining and clustering techniques are based on unstructured data, which is the text of patent documents, and aims to group patents according their similarity of subject matter.

All the patent indicators presented above can be used to examine companies' patenting strategy from different perspective (e.g. technology, marketing, human resources, etc.) and provide an interesting in-depth assessment of the characteristic of patent portfolio. In order to achieve a complete benchmark of companies' patent portfolio, technological positions have been identified and evaluated by taking several indicators into account. These patent indicators are combined together to reduce the variance of measurement errors offering a benchmark of

the activity level of R&D efforts and its differentiation according to the achieved quality of the overall position relative to the competition. The benchmark of patent portfolio shows the competitive position of a firm in a technological field, facilitates the identification of leading firms and the measurement of technological distance among competitors.

The application of patent intelligence methodology on Brembo case study permitted to compare the patenting strategies among considered companies. Patent indicators show strength and weakness of each company's patent portfolio and provide a comprehensive overview about competitive environment. From these findings companies can easily determine corrective actions that should be carried out to improve their patenting strategy and R&D efforts.

Nevertheless, a complete patent analysis should not be solely based on technological considerations but it should also take market perspective into account. Integrating the patent analysis and market data can help to verify the trade-off between patent efforts and market results and to evaluate the technological condition of a market in order to identify potential opportunity and future outcome. The joined examination of patent documents and market information completes technological considerations adding value from a business perspective. The integration of these two sources of information is useful to understand competitive positioning, growth opportunity and industry trend. This approach has been applied for technology evaluation of Chinese automotive market, focusing in particular on braking systems.

Despite an extraordinary number of filings by local car manufacturers, there are reasons to concern about their technology level. From a patent-perspective, Chinese car manufacturer are not developing brake technology internally, but the indigenous innovation policy and the technology transfer through JVs are quickly evolving technological environment. In the next years, their continuous improvement might take Chinese market to higher quality standards offering a valuable growth opportunity for international OEMs and components suppliers; although Chinese companies will acquire and develop their own technology and will set a tougher and competitive environment, raising pricing pressure for international companies also in their established markets.

Ultimately, patent intelligence can be exploited for competitive benchmarking but also for technology evaluation of emerging markets. Patent indicators and positioning of patent portfolios on the company level should become a core element of balanced scorecards for top management and decision-makers. Therefore, it appears necessary to examine in depth the dissemination and communication of patent intelligence outcomes through various levels of the organizations.

Appendix 1 – Patent information

Patent fields are uniform among patent documents issued by national patent authorities and can be divided between structured data – also referred as bibliographic data – and unstructured data, which are text in natural language related to the invention.

Structured data

Priority date: the priority date is the date of filing of earliest patent application. In first-to-file systems, the priority date corresponds to the filing date. In first-to-invent systems, the priority date is effectively the earliest date upon which the invention was conceived.

Application date: date when a patent is filed at a specific patent office.

Publication date: date when a patent application is made available to the public.

Applicant(s): a legal (i.e. company) or natural (i.e. person) entity that files an application for a patent, utility model, trademark or industrial design. There may be more than one applicant in an application.

Kind codes: for most patenting issuing authorities, more than one document is issued for any particular patent (e.g. patent application is frequently published before examination, then patent specification is released after grant). As these sequential documents often keep the same number, a method was devised to distinguish between them by adding a letter immediately after the number. Kind code follows the publication number and comprises one letter and one digit. Commons patent document kind codes are A1 (patent application published with search report), A2 (patent application published without search report), B1 (patent specification for granted patent).

International Patent Classification (IPC): patent classification schemes are used to organize and index the technical content of patent specifications to favor the identification easily and accurately. The principal patent authorities have their own classification scheme. Predictably, there are some discrepancies between regional schemes. Therefore, in order to catalogue all patents in a uniform manner, WIPO promotes and administers the International Patent Classification (IPC), which is worldwide adopted and virtually every patent is categorized using this scheme. IPC symbols are assigned according to technical features in patent applications. A patent application can be assigned multiple IPC symbols, as it may relate to multiple technical features. The IPC divides patentable technology in eight key areas, which are subdivided to a detailed level and allows the disclosed invention to be thoroughly classified. The IPC's

hierarchical structure consists of sections, classes, subclasses and groups. Sections are the highest level of hierarchy of the classification and are designated by one capital letter (A-H). Section are subdivided into classes, which are the second hierarchical level of the IPC, class symbol consists of two-digit number. Each class comprises one or more subclasses that are the third level and are represented by a capital letter. In turn, each subclass is broken down into subdivisions named groups, which are either main groups or subgroups. The group symbol consists of two numbers separated by an oblique stroke. For the main group, the symbol is a one-to-three digit number followed by an oblique stroke and double-zero. The subgroup is identified by the one-to-three digit number of its main group, the oblique stroke and a number of at least two digits other than double-zero. Subsequent digit after the oblique stroke is to be understood as a decimal subdivision of the digit preceding it. Every section has a title, going from a very broad indication for the section to a very precisely title of the subgroup.

Example of complete classification symbol comprises the section, class, subclass, main group and subgroup.

F16D55/228

Section: F – Mechanical engineering; Lighting; Heating; Weapons; Blasting

Class: F16 – Engineering elements or units; General measures for producing and maintaining effective functioning of machines or installations; Thermal insulation in general

Subclass: F16D – Couplings for transmitting rotation; Clutches; Brakes

Main group: F16D55/00 – Brakes with substantially-radial braking surfaces pressed together in axial direction, e.g. disc brakes

Sub group: F16D55/228 – Brakes with substantially-radial braking surfaces pressed together in axial direction, e.g. disc brakes with axially-movable discs or pads pressed against axially-located rotating members by clamping an axially-located rotating disc between movable braking members, e.g. movable brake discs or brake pads with a separate actuating member for each side.

Text fields

Title: the name of the inventions as provided by the applicant

Abstract: a single paragraph describing the invention written by the applicant and reported on the front page of patent application.

Description of the invention: the description explains the inventive step and how it works, with numbered reference to drawings.

Claims: the scope of the patent is set out by its claims. Claims are required to be a one-sentence description of the invention. The first claim describes the highest inventive step of the patent and may be followed by as many claims as are necessary to describe the different aspects of the inventive step.

Appendix 2 – Table

All the following table refers to the studied patent collection of 1886 patent families.

Distribution by priority year				
Priority Year	**Assignee**			
	Akebono	Brembo	Continental Teves	Knorr Bremse
1990	13	2	2	17
1991	13	4	7	17
1992	4	1	11	36
1993	13	2	7	20
1994	23	2	9	14
1995	47	1	16	14
1996	60	2	25	8
1997	30	9	22	11
1998	47	13	26	16
1999	34	14	36	18
2000	26	20	33	13
2001	16	24	25	19
2002	7	15	46	29
2003	11	29	28	28
2004	14	10	23	46
2005	28	10	29	48
2006	45	10	34	39
2007	47	13	17	57
2008	55	8	17	67
2009	29	12	13	35
2010	35	13	16	34
2011	7	7	10	22
2012	1	0	0	0

Distribution by priority country					
Country Code	**Assignee**				**Total**
	Akebono	Brembo	Continental Teves	Knorr Bremse	
DE		13	436	585	1034
JP	591	2	1		594
WO		91	2	1	94
IT		50			50
EP		43	4	2	49
US	11	9	8	14	42
GB	1	10			11
AT				2	2
FR				2	2
IN	2				2
CZ				1	1
HK		1			1
HU				1	1
KR			1		1
PL		1			1
RU		1			1

Distribution by publication country					
Country Code	**Assignee**				**Total**
	Akebono	Brembo	Continental Teves	Knorr Bremse	
DE	45	120	438	579	1182
JP	588	96	117	113	914
EP	30	168	182	410	790
WO	23	164	189	300	676
US	77	115	149	227	568
AT		98	10	180	288
CN	23	34	48	71	176
AU	4	66	8	75	153
BR		6	24	92	122
ES	2	27	22	57	108
IT		59	2	3	64
KR	2	2	44	16	64
CA		2		51	53
MX		7	7	32	46
IN	2	5	6	32	45
RU		4	5	35	44
FR	10	3	3	12	28
CZ		1	14	14	29
GB	7	13	2	3	25
HU			3	9	12
TR			2	9	11
PT			1	10	11
PL		4	4	4	12
DK		1		8	9
SK			7	2	9
HK		1		6	7
SI				7	7
TW	3	2		1	6
AR		2	2		4
CS	1		1	1	3
ID	3				3
ZA		1		1	2
SE				2	2
NO				1	1
SU				1	1

Distribution of Chinese patent by publication year				
	Assignee			
Publication Year	Akebono	Brembo	Continental Teves	Knorr Bremse
1995				
1996			1	
1997				
1998			2	
1999			3	
2000		1		1
2001			1	
2002		1	1	1
2003		3		2
2004		1		1
2005	4		3	4
2006	7	4	2	6
2007	2	2	4	8
2008	2	1	5	4
2009	3	4	10	4
2010	1	4	5	11
2011	1	4	5	17
2012	2	8	5	10
2013	1	1	1	2

Trilateral and quadrilateral filings			
Assignee	**Trilateral filings**	**Quadrilateral Filings**	**Others**
Akebono	19	8	586
Brembo	74	22	147
Continental Teves	96	34	356
Knorr Bremse	93	29	515

Legal status					
Assignee	**Granted**	**Pending**	**Revoked**	**Expired**	**Lapsed**
Akebono	168	164	14	20	239
Brembo	152	43	1	6	19
Continental Teves	173	138	17	5	119
Knorr Bremse	365	139	36	22	46

Top 10 IPC Group					
IPC Group	**Assignee**				**Total**
	Akebono	Brembo	Continental Teves	Knorr Bremse	
F16D-065	511	189	258	528	1486
F16D-055	260	87	119	257	723
B60T-013	16	6	124	67	213
B60T-008	16	5	103	40	164
F16D-066	29	17	34	65	145
F16D-069	45	41	16	27	129
B60T-017	0	0	46	67	113
B61H-005	55	0	0	58	113
B60T-001	15	8	24	60	107
F16J-003	3	1	3	29	36

Portfolio maturity				
Patent family age	**Assignee**			
	Akebono	Brembo	Continental Teves	Knorr Bremse
0 < Patent family age < 5	113	39	53	135
5 ≤ Patent family age < 10	157	67	129	232
10 ≤ Patent family age < 15	118	91	165	102
15 ≤ Patent family age < 20	186	16	85	66
Patent family age ≥ 20	31	8	20	73
Average patent family age	11,36	9,91	11,21	10,00

Patent portfolio on the company level

Assignee	**Patent quality index**			
	Share of granted patents	Share of trilateral filings	Avg. number of IPC Class	Age-weighted citations
Akebono	27,8%	3,1%	2,04	1,05
Brembo	68,8%	33,5%	1,70	0,35
Continental Teves	38,3%	21,2%	2,08	1,22
Knorr Bremse	60,0%	15,3%	1,73	1,01

Assignee	**Relative patent quality index**			
	Share of granted patents	Share of trilateral filings	Avg. number of IPC Class	Age-weighted citations
Akebono	0,57	0,17	1,08	1,16
Brembo	1,41	1,83	0,90	0,38
Continental Teves	0,79	1,16	1,10	1,34
Knorr Bremse	1,23	0,84	0,92	1,11

Assignee	**Relative patent applications**	**Relative patent quality index**
Akebono	1,28	2,98
Brembo	0,47	4,52
Continental Teves	0,96	4,39
Knorr Bremse	1,29	4,10

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List of abbreviations

EPO	European Patent Office
GDP	Gross Domestic Product
IP	Intellectual Property
IPC	International Patent Classification
IPR	Intellectual Property Rights
JPO	Japan Patent Office
JV	Joint Venture
KIPO	Korean Intellectual Property Office
OECD	Organization for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
PCT	Patent Cooperation Treaty
R&D	Research and Development
S&T	Science and Technology
SIPO	State Intellectual Property Office of P.R.C.
TRIPS	Trade-Related aspects of Intellectual Property rights
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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