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The patent portfolio value analysis: A new framework to leverage patent information for strategic technology planning

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ABSTRACT

Patents and patent portfolios are valuable assets. Companies need a conceptual structure to assess the value of their patent portfolio. This paper develops a practical and reproducible framework that can support scholars and practitioners to leverage the value of patents and to extract all possible strategic information from patent portfolio. The patent assessment process aims at comparing and contrasting the management of patents to the company's technologic and innovative strategy. The framework employs determinants of patent value that are elicited from patent databases, such as claims, citations, and market coverage, and that are expressed in terms of judgments achieved by interviewing involved managers, such as strategic relevance and economic relevance. The paper examines the main methodological issues in assessing patent portfolio value then, it describes the characteristics of the framework; subsequently, it illustrates the implementation of the proposed framework into two companies which operate in the aerospace and defense sector. The two implementations show that the framework can be used for strategic planning and strategic technology management.

1. Introduction

A number of articles show that management of knowledge assets, in general, and patents, in particular, are increasingly important, as the value of knowledge intensive companies is partly determined by the value of their patents. Today, a few organizations have made significant investments in training human resources to manage and evaluate patents and patent portfolios, and it would be extremely advantageous that these efforts be emulated by plenty of other business companies. Literature on the value of patents has proposed different methodologies of evaluation: qualitative and quantitative and monetary and non-monetary (Sapsalis et al., 2006; Sapsalis and van Pottelsberghe de la Potterie, 2007). The choice of a method often depends on the purpose of the valuation and includes market transactions, financial reporting, estimation of damages for infringement, or financial access. Basically, it is possible to say that patents can assume different values depending on the purpose and the context of the evaluation (Harhoff et al., 2003). Different methods of patent portfolio evaluation have been proposed in literature to meet the needs of different business issues, such as motivation of employees; attraction of customers, partners, and investors; intimidation of competitors; access to third party technologies and generation of income (Hall et al., 2005). However, the analysis and the understanding of the intrinsic value of a patent portfolio for internal business purpose have been little explored in literature, both from a theoretical and a practical point of view. This is confirmed by the fact that the assessment of the potentiality of a portfolio to sustain a company's strategic business has not been explored thoroughly yet. This preamble suggests that while many aspects in a company are considered to be valuable factors, such as legal advice, technological aspects, and scientific and bibliometric issues, patents and patent portfolios, too, should be considered as relevant in fostering the value creation process in a company. Indeed, data from a patent, such as technological innovation,

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scientific research and results, investments and economic returns, can be put together and processed in order to generate strategic information.

However, the objective of this paper is not to measure the value of a patent portfolio or decide which data are to be analyzed to assess it. The aim of this paper is to assess the perceived value of a patent portfolio and extract information from its data following an internal business perspective. In order to do this, it is necessary to understand the value of the patent portfolio deeply, to manage it strategically, and to grasp its strength and weaknesses, so that its patent catalogue data can be improved. This means that the strengths of patents and patent portfolios and the solution to their weaknesses must be exploited; that decisions on selling or keeping a patent should be taken fittingly and that the modalities of negotiating license agreements with partners must be evaluated appropriately. So, the analysis of the perceived value of a patent portfolio can help clarify decision making processes and define the best patent strategy in a company. Moreover, the analysis of a patent portfolio can improve the patent and patent portfolio management and make the intellectual property portfolio structure more clear in order to take on the competitive landscape.

Patent portfolio assessment is a business responsibility, and the concept of value is here intended as the power of patent portfolios to support the company's value creation process and its strategic business objectives. On this purpose, the patent portfolio assessment process needs other data in addition to objective and quantitative data, such as bibliometric, financial, and technological data. The process also requires the involvement of those decision makers who can supply their judgments to the highest degree of completeness, precision, and accuracy, based on the strategic business and economic relevance. Analyzing all these aspects means making an investment in the knowledge of a patent portfolio and to enable its better leverage and, consequently, to reduce the risk of taking inappropriate strategic measures.

This study therefore proposes a framework which supports companies in assessing the perceived value of patent portfolios. The intention of this paper is to take strategic information out of patents in order to support the managers' decisional process for patent management and verify their accordance with the technologic and innovative strategy in the company. The framework is innovative in that it combines the economic–strategic and the technologic–bibliometric perspectives to leverage the value of patents appropriately. In order to do this, five features have been selected in this *ad hoc* tailored framework, which is based on a multiple criteria principle: two qualitative features relate to the economic–strategic perspective and three quantitative features relate to the technologic–bibliometric perspective.

The contributions of this paper are the following. It summarizes the theoretical analysis of the literature regarding the five identified criteria and supplies a methodological framework to get a synthetic graphic representation from the combination of quantitative and qualitative analyses. More specifically, the framework aims to help managers make strategic decisions by the combination of the economic–strategic judgments with the bibliometric–technological information. Then, the application of the framework is illustrated. The findings of this work can provide useful insights into the matter, and be of help to a company's management as to who is in charge of patent portfolio control.

The remainder of the paper is organized as follows: Section 2 reviews the literature of patent value and discusses the rationale by which the five criteria will be selected. Section 3 describes the framework. Section 4 analyzes a practical implementation of the framework into two companies operating in the aerospace and defense sector. Finally, conclusions are drawn in Section 5.

2. Literature review

A large number of researchers have acknowledged the importance of finding a method to assess the value of patent portfolios as a result of the increase in patent applications and the awareness that patents are substantial tools to study the evolution of technology within markets. Since the proprietary technology is considered as a decisive factor to achieve market success and a valuable asset to many industries, benchmarks of patents provide useful insight into the competitive position of a company (Ernst, 2001) while patent portfolio assessment represents a promising way to compare technological know-how of companies objectively (Campisi et al., 1997; Ernst, 2003; Fabry et al., 2006). Moreover, as patents normally anticipate the real use of technologies in commercial applications, benchmarks may also have the function to give a first outlook into the future competitive landscape (Ernst et al., 2010).

Studies regarding patents for the strategic technology planning can follow two main approaches: the bibliographic approach and the value creation approach. The bibliographic approach uses bibliographic patent information including citations, applicants, inventors, and international patent classification codes. Although it is widely used to identify criteria such as International Patent Classification (IPC) class, inventors, and assignee, the bibliographic approach cannot either identify detailed technological features or provide significant knowledge of the value of a portfolio (Lee et al., 2009a). However, the bibliographic approach can be extended by the content-based approach to emphasize technologically significant patterns, trends and opportunities by extracting useful information such as abstracts, detailed description of invention, geographic protection and claims from patent text (Yoon et al., 2011).

From the value creation approach, patent literature is focused on the estimation of the economic and strategic value of patents, by making use of databases or surveys, and on the evaluation of the impact of innovation and technology on the company value. A few methods belonging to this approach are used to investigate different determinants and patterns in relation to patent value (Lanjouw, 1998; van Zeebroeck, 2012) or to transform patent data into useful information to manage intellectual property and analyze market competition (Chakrabarti and Dror, 1994; Hall et al., 1986; Tseng et al., 2011). Some of these approaches recognize the importance of managers' perception of the strategic and economic relevance of patents for an internal assessment of intangible assets (Grimaldi et al., 2012; Reitzig, 2003).

In conclusion, we noticed that there was a need for more research frameworks based on the analysis of both objective data, such as technologic–bibliometric information, and strategic–economic information, derived from the patent value creation analysis. In order to take account of both approaches and to consider all the fundamental elements regarding strategic technology planning, we selected five criteria: claims, citations, market coverage, strategic relevance, and economic relevance. The first three refer to

bibliometric information and help analyze those aspects which pertain to the technologic and scientific innovation and the geographic coverage of patents; the last two refer to the strategic–economic information. More specifically:

- from the analysis of claim information data, it is possible to derive the technologic importance of its innovation and the dimension of the company's technical abilities;
- from the characteristics of citations, it is possible to analyze the originality and the relevance of an innovation and assess the importance of its possible links to future patents;
- market coverage information gives the extent of worldwide patent protection and the level of the assignee's investment;
- the strategic relevance information data allow the assessment of the strategic importance of patents within the value creation process;
- the economic relevance information data allow the discussion about market value and financial performance of patents.

In the following sections, we explain the importance of the five criteria for strategic technology planning in more detail.

2.1. Claims

In technical terms, claims of patents define the range of their protection. In other words, claims are related to product, process, and usage of patents and delineate the property rights protected by the patent (Haupt et al., 2007). The growing importance of the role of claims of patents for strategic technology planning is proved by the average number of claims per application that has increased three times from 1990 to 2009 (Blackman, 2009).

Many authors hold that the value of a patent or of a patent portfolio can be leveraged by a large number of claims (Tong and Frame, 1994; OuYang and Weng, 2011). Lanjouw and Schankerman (2004) observe that claims reflect the technological importance of the innovation and that the number of claims shows that an innovation has a wide potential of profitability embedded in it. Lerner (1994) and Shane (2001) assert that only highly valued patents underpinned by several technical claims make companies' financial value increase.

The number of claims changes substantially as a result of the technology field of the patent (Ernst, 1998) and is indicative of the scope or width of the patent itself (Park et al., 2005). Likewise, the number and quality of claims of the patent portfolio can also be an indication of their value (Lagrost et al., 2010).

2.2. Citations

The analysis of patent citations helps assess the usefulness, the originality, and the relevance of an innovation and furthers a map of the connections which are established between future patents. Citations have an important legal function, as they both delimit the scope of the property rights awarded by the patent, and are distinctive of the consolidated technological background of the patented innovation (Hikkerova et al., 2014). Citations of patents are commonly divided into two classes: backward and forward citations. Backward citations are all those documents (other patents or scientific papers) cited by the patent. Forward citations are all those citations received by other patents and documents. The citations received by a patent have an essential role in the analysis of its quality, as they give the dimensions of its impact on the current technology and of its applicability to further related studies (Harhoff et al., 2003).

Several scholars agree on considering citations and number of citations as important proxies not only to value a patent and assess a patent portfolio, but also for strategic technology planning. However, it is important to emphasize that it is difficult to assess the value of a patent on the mere count of its backward citations, while forward citations appear to be more reliable and able to assess the value of a patent. To this end, Guan and Gao (2009) proposed the application of the bibliometric h-index (Hirsch, 2005) to patents: a group of patents has a level of this index equal to h, if h patents receive at least h citations from later patents, while other patents receive no more than h citations. The limit of this method is that it is necessarily related to a group of patents (van Zeebroeck et al., 2009).

However, also forward citations show some bias: the main problem is how to scale the time lag since the “citation lag” is a matter of weight. In other words, not all the received citations are equally important, because the number of citations is often strictly dependent on the patent age. Conceding that younger patents are bound to receive fewer citations than older ones, some studies suggest that the temporal lag aspect in the distribution of forward citations be considered (Marco, 2007). Some scholars tried to work citation lag problem out by finding an approximation of citations received over the years. Among others, Trajtenberg (1990) was one of the first scientists to analyze the impact of the lag on the citation process. Gay et al. (2005) verified “a clear link between the average number of citation per patent and the length of the lag before first citation”. Moreover, since the propensity to cite may grow as a result of reasons not related to patent quality, and since the number of citations makes the hazard rate increase, Hall et al. (2005) postulated that the number of forward citations should be normalized by age.

2.3. Market coverage

Patents are characterized by their spatial boundaries among which also the boundaries of countries are included. Indeed, the effect of a patent is delimited by the extension of the territory of the state that licensed the patent. Companies or inventors, whose activity stands in relationship to international markets, need to protect their inventions by sole right in all those countries where they want to market their products. Therefore, to protect an innovation in multiple countries a patentee should secure a patent in each country. For this purpose countries negotiate international agreements on standard operative procedures in order to settle the industrial properties rights of patents (Meyer et al., 2011).

For the patent value, there appears to be evidence that the extent of worldwide patent protection strongly influences patent role in the strategic technology planning: the broader the geographic protection, the greater the competitive impact of the patent. According to Putnam (1996), the quality of a patent derives also from the number of countries in which the patent is taken out. The coverage of the market is then a measure of the extent of patent protection in global markets (Ernst and Omland, 2011). Also, several researches indicate that the value of patents is related to the number of countries in which those patents are filed (Harhoff and Hoisl, 2007; Lanjouw and Schankerman, 2004; Lanjouw et al., 1998; Reitzig, 2004).

2.4. Strategic relevance

Patents, as any other asset, can be used to get an advantage over competitors; this competitive advantage can be interpreted both as the result of a differentiation strategy against competitors and as a source of revenues from the grant of patents to a third party (Lee et al., 2009a). And this gives evidence of the strategic relevance of patents in the value creation process. Companies understand the advantage of protecting their patent rights, but at the same time often underestimate their value. As some authors suggest, companies should consider patents as strategic tools to pursue their objectives (Lee et al., 2009b; Tseng et al., 2011). In this regard, Ernst (1998) showed how patent information can be used to monitor competitors, assess technology, and manage R&D portfolios. It is evident that these activities call the attention of managers and decision makers to establish a successful strategic technology planning. In particular, the involvement of managers from innovation and Intellectual Property (IP) fields makes these decisions actual and idiosyncratic on the basis of their dynamic viewpoints.

From this perspective, although empirical research shows that patent information is rarely used in strategic planning (Ernst, 1998), some authors point out that several managers acknowledge the benefits of patents as a strategic information source and are aware of the fact that the crucial role of patents depends on different judgments. Undoubtedly, patents can encourage innovation and valorization of research activity, and can address the coordination of technological flows within companies or research groups (Gilardoni, 2007), while the exclusivity of an innovative product can help reach a leading or competitive position over the main competitors. Moreover, those patents that are not exploited directly by owners because they are not considered strategic to their companies, can be capitalized by licensing them in several countries. Arundel and Patel (2003) focused on companies' defensive and offensive patent strategies. For instance, filing a patent can be a hindrance to the competitors and cause a deterrent effect (Hsieh, 2013). Furthermore, Breitzman and Thomas (2002) described how the analysis of company patent portfolios can encourage the evaluation of mergers and acquisitions. Lastly, patents can be valorized as a source of patrimonial estate, as elements of exchange with competitors, or as key factors that increase the value of a corporate image in possible future negotiations (Davis, 2008).

2.5. Economic relevance

In the strategic technology planning the economic relevance of a patent is to be considered as a significant criterion. In literature, the methods proposed to evaluate the economic significance of patents can be divided into two groups: quantitative or qualitative (Kamiyama et al., 2006). Quantitative methods can be described as techniques using numerical information based mainly on the three classical approaches – cost, market and income – to provide an objective measure (Lagrost et al., 2010). Qualitative methods determine the value of the patent by understanding its processes and context of application and by examining other non-numeric characteristics. These methods provide an interpretative and subjective evaluation generally not expressed in monetary terms.

On the one hand, it is necessary to consider that the use of only quantitative methods will neglect non-measurable factors which may be important to an organization to understand the complete value of the IP; on the other, many scholars argue that there is only one way to evaluate a patent: the quantitative methods (Lagrost et al., 2010). However, it is also important to highlight that making a choice between the two options is not an appropriate procedure. In respect of this point, Trochim (2006) argues that qualitative data can be coded quantitatively when quantitative information is based on qualitative judgment.

Another dichotomy characterizes the economic value of a patent. Effectively, it depends, in turns, both on the technical–industrial and commercial factors. The technical–industrial value of the invention depends on many factors: its degree of technical originality; technical advantages deriving from the application of the invention to manufacturing processes or products and the industrial and competitive advantages resulting from exploiting the invention (Hanel, 2006). In literature many authors resort to study the impact of innovation and IP rights on company value by putting different features of patents into correlation with the company value (Trajtenberg, 1990; Lerner, 1994; Lanjouw and Schankerman, 2004; Hall et al., 2005), or surveyed monetary appraisal by inventors in the attempt to validate the use of more accessible data in value-weighting schemes. In regard to the commercial value of the invention, it can be determined by making a projection of the amount of business to be achieved by exploiting the invention and commercializing the product, and by overviewing the indirect amount of business of the possible license of the patent (Jolly, 2012). Literature on this topic has focused on the estimation of the economic value of patents, based on different pieces of information within patent databases and patent families (Putnam, 1996; Harhoff and Reitzig, 2004, 2005) or on field surveys (Harhoff et al., 2003).

In conclusion, some limitations of the assessment and exploitation methodologies of patents exist. Empirical and theoretical researches show that:

- patent information is not frequently used in strategic planning and managers have few multiple-criteria implements available to assess the patent portfolio;
- company and managers do not have a managerial procedure available to assess the value of patent portfolio as perceived by managers;
- company and managers do not have a strategic framework available to verify the alignment of patent strategy and business strategy;
- the existing systems do not consider either quantitative (citations, claims and market coverage) or qualitative (economic and strategic relevance) features of a patent at the same time;
- the existing tools do not synthesize the results of multiple criteria into a single procedure so that the strategic assessment of decision makers can be easily supported.

In conclusion, it is necessary to devise a framework which assesses patents and patent portfolios in a strategic way and which includes the characteristics of a multiple criteria approach based both on quantitative information derived from objective data, and strategic and economic information derived from decision maker perceptions and judgments. This framework should give an actual and dynamic assessment of patents and patents portfolios and provide a synthesis of the multiple criteria method.

3. Developing a new patent portfolio assessment framework

In the following sections of the paper, we will discuss our methodological framework in detail by investigating the characteristics of a patent portfolio both qualitatively and quantitatively. We added more patent data information by including in our information datasets the results derived from the answers of the managers interviewed on their perceptions of the value of patent characteristics. We identified five key criteria which can encompass crucial information to the acquisition of a deep knowledge of patent portfolios: 1) technical scope; 2) forward citation frequency; 3) international scope; 4) patenting strategy, and 5) economic relevance. Then, we synthesized the results achieved by the five criteria of analysis to examine the perceived value of the patent portfolio and to assess and exploit the patent portfolio management as part of a business strategy.

3.1. Technical scope (TS)

Claims indicate the broadness of the technology protection of the patented innovation. To assess the value of a patent the importance and quantity of claims should be considered as important proxies.

The number of claims of a patent is traceable in most of the patent databases and depends on the technological field within which the patent is pending. Therefore, the claims are to be searched for both in the specific field of interest and in the correlated technologies of the invention. Indeed, the value of the number of claims could be substantially different within the classes of the International IPC. Consequently, it is necessary that the value of claims be normalized for the number of technologies, and, also, that a comparison between patents belonging to different classes be carried out.

In order to do this, we normalized the value of the number of the claims for the maximum number of claims of a patent of the same company belonging to the same IPC class, as seen in Eq. (1):

$$\mathrm{TS} = \frac{\text{number of claims}}{\text{maximum value among the number of claims for the company and for the same IPC class}}. \tag{1}$$

According to Eq. (1), the value of TS of a patent is comprised between 0 and 1. The greater the value of TS, the greater the number of patent claims within the company and the IP class. TS assumes a value of 1 when a patent has the maximum number of claims within the company and the IP class. Consequently, the value of TS for a patent portfolio is equal to the mean value of the indicator of TS of all the patents of the portfolio.

3.2. Forward citation frequency (FCF)

Citations are broadly considered as the answer of the given technology over the successive inventions or competitors. Even if either backward or forward citations can be a measure of value, we decided to rely only on forward citations. The decision was motivated by the twofold nature of backward citations and of self-backward citations. Both of them may represent an advancement of an already developed technology, but may also be a sign of stagnancy of technology and innovation, since many other studies could have been made a long way back.

As stated in Section 2, most of literature agrees upon the importance of citations in the study of patent value. However, the construction of an indicator able to represent the impact of citations on patent value is subject to different opinions. In particular, following the thoughts by Hall et al. (2005) about time lag and those by Gay et al. (2005) about the citation lag, we chose to assess FCF as the average number of annual forward citations received by a patent:

$$\mathrm{FCF} = \frac{\text{number of forward citations}}{\text{age of the patent}}. \tag{2}$$

More in detail, we thought that, for calculating the number of the forward citations, it was necessary to consider the age of a patent, in order to take into account both the time lag principle, which suggests that the older the patent, the higher the probability of receiving citations, and the citation lag principle, which affirms that a patent needs time to be cited and receives very few citations within the first years since it was granted.

According to Eq. (2), the indicator expresses the average annual value of the number of citations of a patent. However, as the rate of citations is very different across different technologies, we decided to normalize the values of each separate IPC class by using a min–max normalization. We therefore obtained the outputs of FCF rescaled from a variable range of values into a new range of values that lay within a range from 0 to 1. We chose the min–max normalization as it preserves all the relationships in the data exactly; moreover, it makes it possible to assign the unitary value to the maximum value among the FCF values, and to assign the null value to that value which has the minimum value within the same IPC class.

The FCF indicator of a patent portfolio is obtained from the mean of each value of the indicator of FCF of all the patents of the portfolio.

3.3. International scope (IS)

The geographic extent of a patent is proportional to the success of an innovation. Since the aim of this framework is that to analyze the value of patent portfolios from a business perspective, we decided to evaluate the geographic coverage and protection by

considering both dimension and quality of markets. IS value is the sum of two addends, as shown in Eq. (3) and assumes a value comprised between 0 and 1.

$$IS = IS_a + IS_b. \quad (3)$$

The two addends are characterized by different purposes and different relative significance. IS_a accounts for the number and type of the countries covered by the patent and can assume a maximum value of up to 0.7. IS_b is a value to be added to IS_a and can assume a maximum value of up to 0.3. In detail, we chose to assign IS_a a value comprised between 0 and 0.7 in dependence of the number of those countries where the patent has been granted. The calculation of the value of this addend and of the value to assign each country depends on the technologic/geographic characteristics of a specific analyzed sector and on the competitive dimensions of the companies that operate in that environment. The second addend IS_b is a dummy variable which takes a null value or a 0.3 value in dependence of two different situations of patent granting: the triadic share and the Patent Cooperation Treaty (PCT) procedure. According to Ernst (2001), a patent reaches the triadic share when it is granted at the EPO (European Patent Office), the USPTO (United States Patent and Trademark Office) and the JPO (Japan Patent Office). For a patent, the triadic share is a universal sign of quality in terms of international coverage. Consequently, if a patent reaches the triadic share, IS_b is given a value of 0.3. However, if a patent does not reach the triadic share, it is necessary to ascertain if the patent has been signed for a PCT procedure. Basically PCT is a procedure applied to the WIPO (World Intellectual Property Organization) that virtually permits to patent all over the world, within 30 months from the application date. Therefore, if the patent was signed for a PCT procedure less than 30 months before the application date, IS_b is given a value of 0.3. In the case that a patent reaches the triadic share and, at the same time, has been signed for a PCT procedure, IS_b value remains steady at 0.3. This operation is necessary to avoid that the value of IS_b exceeds 0.3 and that of IS exceeds 1, and is compensated by adding a further extra-European country in the IS_a calculation.

It should be noted that the value of IS has to be updated every year, as a result of the continuous evolution of the scenario of companies' business and the change of strategies which rule the modalities of time and place of patenting. The IS indicator of a patent portfolio is obtained from the mean of each value of the indicator of IS of all the patents of the portfolio.

3.4. Patenting strategy (PS)

PS represents the technological importance of a patent both from an internal business and a strategic perspective. Although there is no general agreement about the definition of a strategy for patenting and different approaches can be selected to classify strategic intents to patent, most experts have divided them into offensive and defensive ones (Arundel and Patel, 2003; Gilardoni, 2007; Kingston, 2001; Tseng et al., 2011). More in particular, offensive strategic intents refer to those patents that are purposed to establish and maintain proprietary and competitive positions (Ernst and Omland, 2011; Zahra and Covin, 1993). Defensive strategic intents relate to three different typologies: the aim of safeguarding inventions and their connected business from external competition (Blind et al., 2009; Ernst, 2003); an exclusively defensive aim, directed at protecting developed inventions and blocking other firms from using them (Gilardoni, 2007; Lagrost et al., 2010); a further strategic intent, sometime included in the defensive strategies, according to which a patent is considered as not essential from a strategic point of view but it serves only as a tool for improving the image of a company, without pretending any competitive purpose (Arundel and Patel, 2003; Sullivan, 1998).

As a consequence, to assess the strategic positioning of a patent we decided to make reference to the four typologies as identified in literature, competitive, business, defensive and not essential, and defined as it follows:

- *Competitive*: the patent defends the leading strategic positioning of the company's business by the rights of the industrial property protection and is functional to the company's competitive positioning in the field of technological reference;
- *Business*: the patent protects the strategic positioning of the company's products and is important for the business of the company at the product level;
- *Defensive*: the patent serves the purpose of limiting/precluding solutions to the competitors and/or creating further barriers/difficulties to possible new entries, even though it is not considered as much as important for the business and the strategic position of the company;
- *Not essential*: the patent does not protect the company's competitive position against other companies; it is not significant at the level of technological excellence and/or does not add value to relevant products of the company, but it maintains a certain importance in the portfolio only in terms of corporate image.

PS expresses the strategic importance of that specific technology as it is intended by the company at that specific moment. To ensure that comparison and experience are an integral part of this perspective, the value of PS should be the result of an assessment of a patent portfolio based on interviews. We suggest that the interviewed persons be those top managers who are strictly involved in the management processes of innovation and IP. Each manager is required to select one out of the four levels of assessment among competitive, business, defensive, and not essential, which would fit better with the PS of each patent. In order to evaluate the results deriving from the interviews appropriately, we turned qualitative assessments into quantitative values. Since, as literature suggests, an offensive firm strategy thwarts opponents more strongly than a defensive one, we decided to assign a lower value to the more defensive strategies than to the offensive ones. In order to do this, we attributed quantitative values, equally distributed in the interval comprised between 0 and 1, to the discrete qualitative variables (Table 1); concurrently, we attributed the null value to the minimum value (not essential position) and the unitary value to the maximum value (competitive position) among the possible qualitative assessments.

Table 1
The four values associated with the patenting strategy of patents.

Patenting strategy assessment	Quantitative value
Competitive position	1
Business position	0.66
Defensive position	0.33
Not essential position	0

As illustrated in Table 1, a numeric value expressing the PS is given each patent by each interviewed manager. The mean value of all the numerical values derived from the answers of the interviewed managers corresponds to the value of the PS of each patent. This indicator, at its extremes, will take 0 value when a patent is considered as not strategic or not useful any more to the core business of the company, while it will take 1 when a patent is considered as strategic and in line with the objectives of the company. A classification of patents of a portfolio can be developed by calculating the quantity of the patents belonging to each category. The PS indicator of a patent portfolio is derived from the mean value of the indicator of PS of all the patents of the portfolio.

3.5. Economic relevance (ER)

The ER of a patent describes its current economic value and represents the result of an internal assessment carried out through an economic/technological analysis. Often this analysis is carried on to evaluate how much the company is gaining from innovation derived by the utilization of the patent. Unfortunately, data from sales volume is confidential information and cannot be used in such analysis.

So, even though a standard indication to assess firm patent values from an internal strategic viewpoint is not easily reachable and different methods can be adopted to evaluate the ER of patents, experts suggest to utilize qualitative methods based on the direct discussion with IP managers (Ernst, 1998; Jaffe et al., 1998; Lagrost et al., 2010) or based on questionnaires and surveys (Blind et al., 2009; Hsieh, 2013; Reitzig, 2004). Indeed qualitative approaches require the heavy collaboration of top level human resources involved in IP development and management, and this is precisely why they are specially trustworthy (Hagelin, 2002; Lagrost et al., 2010). As a consequence, we decided to assess the ER of patents by adopting a qualitative method based on the perceptions and judgments expressed by the top management involved in managing innovation and R&D departments, as proposed for the PS in Section 3.4.

As suggested by Hsieh (2013), we decided to use a five-point Likert scale to measure the value of ER. However, to facilitate the assessment process, instead of making use of the traditional five-point Likert scale ("none", "weak", "medium", "strong", "excellent") or ("very low", "low", "fair", "high" and "very high") as suggested in literature (Cricelli et al., 2014; Hsieh, 2013), we decided to employ five qualitative levels more easily and logically linked to the ER of a patent, such as: core, high, medium, low and no relevance:

- *Core*: the patent represents one of the most significant sources of profitability of the company and value for the client and the stakeholders; the very strong economic importance of the patent depends on its technological domain, that is within which range the patent technology and its by-products are exploitable;
- *High*: the patent is able to generate high profitability and a satisfactory level of cash flow deriving from its relevance in the market, that is the success of selling both the product and its technology;
- *Medium*: the patent is still able to generate value but the marketing of its products and technologies faces difficulties; the company should evaluate the opportunity of reinforcing such patent or should sell licenses to players who operate outside of its area of business, such as consortium agreements;
- *Low*: the patent is not profitable anymore but can generate a barely sufficient level of cash flow; this situation is typical of a technologically obsolete patent which is characterized by difficulty in its reinforcement. The company could decide to transfer the ownership of its no-core business Intellectual Property rights to the marketplace;
- *No relevance*: the patent has no longer economic and accounting value.

For each patent, the interviewed person is required to choose one out of the five levels (core, high, medium, low, and no relevance) which characterizes the ER patent better. Moreover, in order to evaluate the results deriving from the interviews appropriately, we turned qualitative assessments into quantitative values.

In order to turn qualitative judgment-based data into quantitative data, we assigned quantitative values, equally distributed in the interval comprised between 0 and 1, to the qualitative discrete variable derived from the assessments (Table 2). We assigned the unitary value to the maximum value among the possible assessments (core) and the null value to the minimum value (no relevance).

As illustrated in Table 2, a numeric value expressing the patent ER is given each patent by each interviewed manager.

The mean value of all the numerical values derived from the answers of the interviewed managers corresponds to the strategy value of each patent. At its extreme, this indicator will return a value of 0 if a patent is thought of as profitless, while it will return a value of 1 if a patent is considered as a fundamental source of company revenues. The ER indicator of a patent portfolio is derived from the mean of each value of the ER indicator of all the patents of the portfolio.

3.6. The patent portfolio value analysis

In order to support the assessment process of patents and suggest the strategic decisions about patent portfolios, we assumed that the perceived value of a patent portfolio is ensued by analyzing the five criteria previously illustrated. In this paragraph, we exemplify

Table 2
The five values associated to the economic relevance assessment.

Economic relevance assessment	Quantitative value
Core	1
High	0.75
Medium	0.50
Low	0.25
No relevance	0

the process through which it is possible to extract the fundamental information to formulate strategic decisions.

We considered the five criteria separately on the basis of their characteristics: PS and ER for their economic–strategic features, and TS, FCF, and IS for their technologic–bibliometric marks. Such distinction refers to the assumption that patents cannot be evaluated without analyzing all the mentioned characteristics. Since the main purpose of this paper is to leverage patent information for strategic technology planning, we decided that it was important to put into evidence the role of the economic–strategic variables. So, we showed the relevance of their role in the patent portfolio value analysis also by means of a chart. To this end, we determined that the information acquired about these economic–strategic characteristics could be plotted into a Cartesian coordinate system, where PS and ER represented the abscissa and the ordinate axes respectively (Fig. 1). In this way, the patents of a company are positioned in the system on the basis of the information acquired about their values of PS and ER.

The possible combinations of low and high values of ER and PS, which can be visualized in the four quadrants of the Cartesian coordinate system, are described as follows:

- High level of PS and high level of ER (valuable): in this area, all the extremely valuable patents of the portfolio for the company core business are located; this occurrence shows that it is necessary to keep investing in technologies and products of such patents since they are very relevant strategically and, in addition, they generate more cash than they require in terms of investments;
- High level of PS and low level of ER (non-performing): in this case, the technology of the patent is not important to the external environment, but it is a core competence for the company; consequently, it is necessary to keep utilizing the patents and the technologies as they seem to be valuable for the company's strategy despite their low economic return; these patents must be analyzed in order to determine whether their investments are strategically sized to the poor ER; anyway, a diversified company should keep these patents in its portfolio as they could ensure future cash generation;
- Low level of PS and high level of ER (non-core): it is the case that the company does not require that technology for its aims, although it still provides economic return; it is necessary to examine technologies and patents which are positioned in this quadrant to evaluate the possibility of lengthening their profitability by marketing investments in order to improve their economic exploitation and to evaluate the convenience of further investments on R&D as well. As an alternative, it could be necessary to verify the possibility of licensing or selling these technologies;
- Low level of PS and low level of ER (non-valuable): these patents do not add any value to the company and are not competitive; these patents are cash traps because of the money tied up in a business that has little potential; the company should consider the opportunity of dismissing them.

Moreover, as each patent is also characterized by its technologic/bibliometric features, we added a third dimension to the bi-dimensional representation in the Cartesian system. Each patent therefore is represented by a bubble, the size of which expresses the value of the three criteria that we discussed previously: TS, FCF, and IS. We assumed that the value of this third dimension is equal to the mean value of the three criteria values. It must be noted that, although in our opinion there is no reason to assign different relative weights to the three criteria values, it would be worthwhile, in the case of specific contexts, to give prominence to relative different relevance by means of different weights.

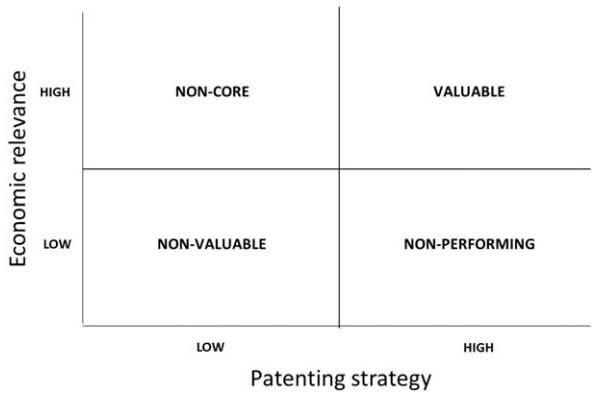

Fig. 1. The four quadrants of the economic–strategic analysis of patents.

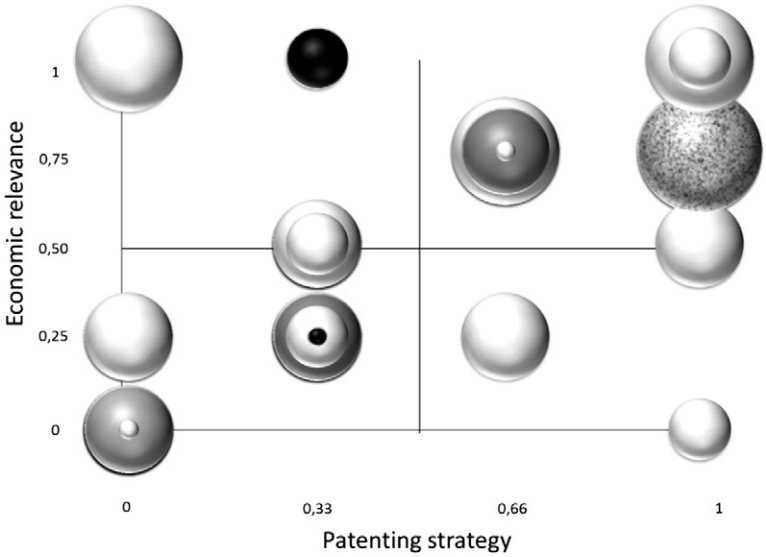

Fig. 2. The patent portfolio analysis.

In order to distinguish the different sizes of the bubbles in the Cartesian system we decided to subdivide the mean values of the third dimension into decimal discrete values. As the illustrative example shows (Fig. 2), it is possible for the managers to visualize the patent portfolio of a company in a single diagram, where the position of the patents is represented by the bubbles plotted as a function of PS and ER values, and the size of the bubbles expresses the range of the mean value of TS, FCF, and IS.

It must be noted that many patents can be located in the same points of the Cartesian system as the values of the two variables in the abscissa and ordinate assume discrete values. This can cause the differently sized bubbles to be placed at the same point of the Cartesian system. Moreover, in order to take the number of patents into due consideration, we decided to characterize the bubbles better by assigning them different colors for different patents. Indeed, it could happen that many patents have the same coordinates of PS and ER and fall in the same interval of the medium value of TS, FCF, and IS; so, each bubble is assigned a color to characterize the number of the patents represented by the bubble.

The representation of the five criteria into the same diagram allows managers to analyze their technologic and geographic importance, in addition to the strategic information deriving from the positions of the patent. As it will be clear in the two applications which we will describe in the following sections, a company can make a precise analysis of its patents only if it combines the information from the strategic–economic and technologic–bibliometric fields in order to extract the strategic information about the true value of its patents. The proposed analysis synthesizes the values of objective data from bibliometrical, technological, and geographic coverage information, along with the values of the strategic and economic relevance achieved from the managers' assessments. Therefore, the strategic decisions which can derive from the analysis account for the value of the patent portfolio from an internal and strategic business perspective, showing their profitability as well. Furthermore, from the synthetic graphic representation it is possible to infer strategic information, which can support the company's value creation process and optimize the structure of the patent portfolio. In particular, it is possible to evaluate the characteristics of the technologic investment and to understand how to leverage the value of the patent portfolio. In other words, the combined analyses previously described can suggest that necessary strategic changes can improve the portfolio value, or that significant actions should be implemented, such as licensing or selling the portfolio, rather than put into production the technology or the invention itself.

Table 3
The values associated with the IS_a deriving from the Delphi survey carried out with the managers of AgustaWestland and DRS Technology.

Number and typology of countries	Value
U.S.A.	0.1
1–2 European countries	0.1
>2 European countries or EPO	0.2
1–2 extra-European and non-USA countries	0.1
3–4 extra-European and non-USA countries	0.2
5–6 extra-European and non-USA countries	0.3
>6 extra-European and non-USA countries	0.4

4. Applying the patent portfolio value analysis to the aerospace and defense industry

We implemented the framework, proposed in the previous section, into two companies, active in the aerospace and defense sector. This sector, unlike other fields such as those oriented to cutting-edge markets (wireless-mobile, consumer electronics, pharmacology, etc.), where patent assessment analysis results in a burst of quality and number of patents, shows features of hi-tech and dynamic characteristics less biased by the specific time-frame observation. We selected AgustaWestland and DRS Technologies for their quality of world players and leaders in Europe and the USA, respectively, in the sub-sectors of vertical lift market and of electronics applied to defense and security. In addition, the patent portfolios of the two companies are highly comparable both for their size (under 500 patent families) and for their time-frame (last 15 years), while their dimensions are balanced enough to prevent the patent analysis from giving rise to too much scattered IPC classes.

4.1. The field of application

4.1.1. AgustaWestland

AgustaWestland is an Anglo-Italian multinational and its main business is helicopter design and manufacturing. It was formed in July 2000 when Finmeccanica and GKN merged their respective helicopter subsidiaries (Agusta and Westland Helicopters) to form AgustaWestland, each holding a 50% share. Finmeccanica acquired GKN's stake in AgustaWestland in 2004. AgustaWestland (AW) operates globally in the vertical lift market through a number of joint ventures and collaborative programs with major European and American helicopter prime companies. AW maintains partnerships with other leading aerospace and defense companies.

4.1.2. DRS Technologies

DRS Technologies, Inc. (DRS), has served the defense industry for 40 years and is a leading supplier of integrated products, services and support to military forces, intelligence agencies and prime contractors worldwide. Focused on defense technology, the company develops, manufactures, and supports a range of systems fulfilling mission-critical and military sustainment requirements, as well as systems that address homeland security challenges. The company holds leading market positions in the key technology areas tied to defense priorities: infrared technology, persistent surveillance, battle management, power technologies, satellite networks and communications infrastructure, and troop sustainment and support.

4.2. Results

To assess the patent portfolios of the two mentioned companies, we carried out the analysis of their patents from May to October, 2013. We analyzed all the families of patents published before March, 2013 by the two companies. We gathered the information data related to the five criteria proposed in the framework from different sources. Some data have been obtained from IP databases; others have been derived from the information acquired by interviewing companies' management.

We collected information data through appropriate queries in the following databases:

- Esp@cenet, a free database that contains patent documents from EPO, WIPO, Japan and U.S.A.;
- Google patents, a search engine that indexes patents from the United States Patent and Trademark Office (USPTO);
- MyIntelliPatent, a software that permits patent analysis by using IntelliSemantic technology;
- InfoPatent, a patent information system developed by the InfoApps GmbH;
- Thomson Innovation, which is a tool owned by Thomson Reuters that makes it possible to conduct deep patent analysis.

Data were successively analyzed and processed to meet the needs of our research. The first step of the analysis involved the identification of the patents of the two companies. The patents were singled out by searching the names of the two companies in the databases fields "Assignee/Applicant" filtered by the field "Publication date" equal to "before March, 2013". Then, by checking out the obtained patent documents with the members responsible for the Intellectual Property Governance boards of the two companies, we collected 105 families of patents of AgustaWestland and 149 families of patents of DRS Technologies.

Afterwards, for each patent, the following information was extracted from the fields of the databases:

- the information necessary to identify each patent family unambiguously, obtained from the fields "Publication number", "Title" and "Inventor";
- the information necessary to calculate the TS indicator, obtained from the fields "Claims count" (to calculate the number of claims) and "IPC class" (to identify the maximum value among the number of claims for the company and for the same IPC class);
- the information necessary to calculate the FCF indicator, obtained from the fields "Count of cited refs — patent" (to find the number of the forward citations) and "Publication year" (to calculate the age of the patent);
- the information necessary to calculate the value of the IS_a + IS_b components of the indicator IS, obtained from the field "Publication country code".

Then, the information to calculate the five indicators were derived as follows. We utilized formulas (1) and (2) to calculate the indicators TS and FCF, as explained in Sections 3.1 and 3.2 respectively.

To calculate the indicator IS, we derived the values of its two addends, IS_a and IS_b, defined in Section 3.3, as follows. We found the necessary information about the triadic share and the PCT procedure of IS_b in the mentioned databases, and we defined the value of the addend IS_a by deriving information about it from the managers of the two companies. Since the value of IS_a is strictly related to the specific context of application, and in consequence of the fact that IS_a assumes a value comprised between 0 and 0.7 in dependence of the number of those countries, where the patent has been granted, we identified an assessment procedure. In order to define the IS_a value, information was collected through a Delphi questionnaire submitted to the members responsible for the

Intellectual Property Governance boards of the two companies. IS_a value resulted from three different contributions:

- a value of 0.1 if the patent is granted in the U.S.A.;
- a value of 0.2 if the patent is granted at EPO or a value of up to 0.2 if the patent is granted in more than 2 European countries;
- a value of up to 0.4 if the patent is granted in more than 6 extra-European and non-USA countries. It should be noted that, in this calculation, we decided to assign Japan a value equals to 2 extra-European countries. This decision derives from keeping in consideration the strategic importance of patenting in Japan, since JPO is one of the patenting offices of the triadic share.

The results of the definition of the values of IS_a and its addends in concert with the managers of the two companies appear in Table 3.

To calculate the PS and ER indicators we derived data from the information obtained by carrying out interviews on the field with the members of the Intellectual Property Governance boards of the two companies, who represent the first level managers directly involved in the technologic and market strategies, such as Heads of Innovation; Heads of Engineering; Heads of Operation; Heads of Strategy; Heads of Business Development and IP Managers.

For each patent, two questions were asked. The first one, relative to the assessment of PS, is as follows:

> Which level of assessment fits best with the patenting strategy of the patent?

The possible answers were "competitive", "business", "defensive" or "not essential".

The second one, relative to the assessment of ER, is as follows:

> Which level of assessment fits best with the economic relevance of the patent?

The possible answers were "core", "high", "medium", "low" or "no relevance".

More specifically, we interviewed four Augusta Westland managers and seven DRS Technology managers about the patents' management. However, operating methods of interviewing the representatives of the two companies have been connoted by different modalities in consequence of differences in their organization structure. AgustaWestland is characterized by organizational functions regulated in a hierarchical and centralized system, while the business and technological management of DRS Technologies is spread across several organizational divisions. Therefore, in AgustaWestland, we carried out eight discussions, each lasting about 2 h, with a team expressly instituted by the top management to assess the patent portfolio value. On the other hand, in DRS Technologies, we carried on seven separate interviews and a few organized workshops of analysis with the specialists of the various units, which ended up with a final plenary discussion, where all data about the patents' assessment derived from previous meetings have been integrated. Each interview lasted about 2 h and the plenary discussion lasted about 3 h.

The results of the application of the framework are described and analyzed in the following sections.

4.2.1. AgustaWestland's patent portfolio value

The patent activity of AW is extremely focused on its main line of business, since the technological solutions in the helicopter sector is very difficult to be transferred to other fields of application. Its patent portfolio is characterized by the following values of the proposed five indicators (Table 4).

The value of TS (0.20) is explained by the singularities of the helicopter sector. Indeed, few players compete in this sector and almost all of them have developed proprietary and fully autonomous solutions to their technologies and competences. Therefore, the high specificity of the patents which pertain to this technological category (fundamentally the "Rotorcraft" IPC) substantiates the little number of patent claims and the low value of TS as well.

The value of FCF is 0.01. Similarly to what has been observed for TS, innovations in the helicopter sector are almost specific and incremental. This fact justifies the uselessness or the lack of concern about citing patents already active and granted by competitors as "prior art". Consequently, these patents show a very low value of FCF.

The value of IS is 0.51. This is due to the wide geographic coverage of the patent portfolio of AW, as shown in Fig. 3. Such a high value of IS depends on two factors. AW registers its patents in all the most important countries in the world in favor of its business and as a protection of its products. Then, AW registers its patents both in those countries where it has a historical industrial activity (such as in Russia), even though this activity is moderate, and in those countries where there is a strong growth rate (such as in China).

The indicators PS and ER show values of 0.73 and 0.79, respectively. For each patent of the portfolio the results of the assessments of PS and ER are synthesized in Figs. 4 and 5.

The high value of PS can be explained through an analysis process of AW's strategy. This company keeps its patent portfolio extremely focused on two typologies of technologies which are fairly shared between those to be developed and marketed in the near future, and those applied to its core business products.

Similarly, and consistently with what has been observed for PS, there is a high portion of profitability in the patent portfolio (about 90%) and this accounts for the high value of ER.

The analysis of AW's patent portfolio has been carried on by combining the five criteria, as outlined in Section 3.6. In Fig. 6, AW's patents are positioned in the Cartesian system on the basis of PS and ER values and are represented as bubbles. The size of each bubble is proportional to the mean value of the values of the other three criteria TS, FCF and IS. Many differently sized bubbles of patents might lie in the Cartesian system at the same points, as they might have the same values of PS and ER but different mean approximated values of TS, FCF and IS. Moreover, it is necessary to highlight the number of patents which have the same coordinates of PS and ER and fall in the

Table 4
The 5 indicators of AgustaWestland.

Indicators	Values for AgustaWestland
Technical scope (TS)	0.20
Forward citation frequency (FCF)	0.01
International scope (IS)	0.51
Patenting strategy (PS)	0.73
Economic relevance (ER)	0.79

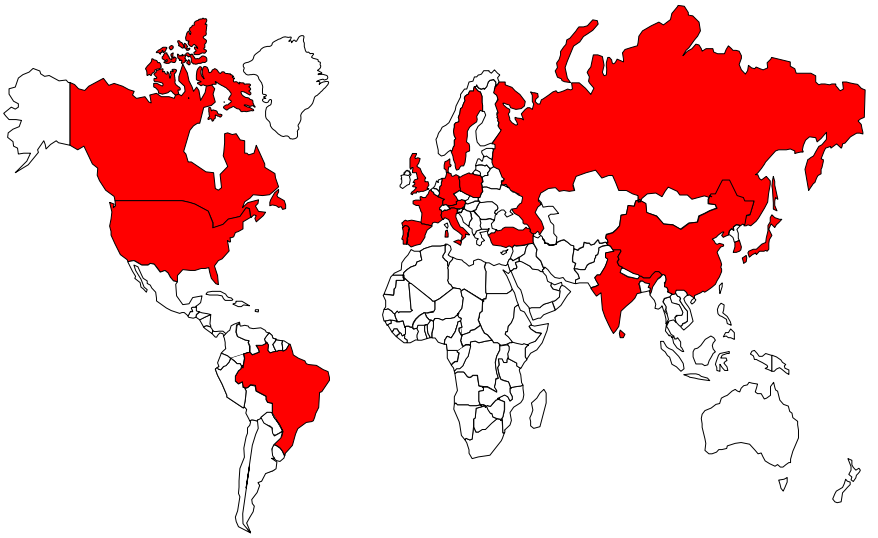

Fig. 3. The geographic coverage of AgustaWestland's patent portfolio.

same interval of the mean value of TS, FCF and IS. So, we distributed the total number of AW's patents in four intervals on the basis of their frequency. We therefore individuated four clusters which have been assigned different shades of gray, as specified in the legend of Fig. 6.

Fig. 6 shows that there are no AW patents at high PS and low ER and that most of them lie in the other three quadrants. This means that the AW patents are characterized by a high consistency between the patent activity and its commercial activity within the helicopter oligopoly. In other words, AW's policy about its patent portfolio is to keep patents which are deeply strategic for its technological requirements and high revenues, and to hold a very small number of patents which are not profitable anymore.

From the analysis of the third dimension (the size of the bubbles) it results that a relationship links the levels of PS and ER of patents and the size of the bubbles. This means that the patents that have been considered as fundamental both strategically and economically are the most appreciated for their technology and valorized in terms of geographic coverage. However, it should be noted that some bubbles with high mean values of TS, FCF and IS are considered as modestly relevant from a strategic point of view. A careful examination should be done in order to understand the reason that, while these patents are considered important by the scientific and technologic community, the company managers do not consider their relevance as strategic.

Ultimately, the analysis of Fig. 6 suggests some remarks about the number and the distribution of the patents. Most of the bubbles that represent a high number of patents are positioned in the upper right quadrant. This is the result of the fact that more than 50% of AW's patents have high-medium values of all the five indicators. This is a further evidence that

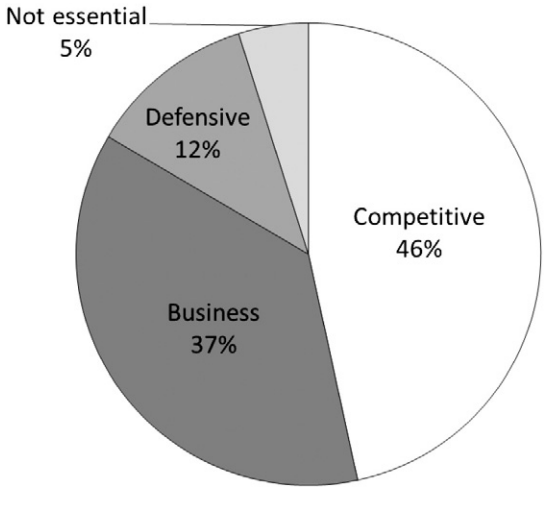

Fig. 4. The distribution of the patenting strategy assessment of AgustaWestland's patent portfolio.

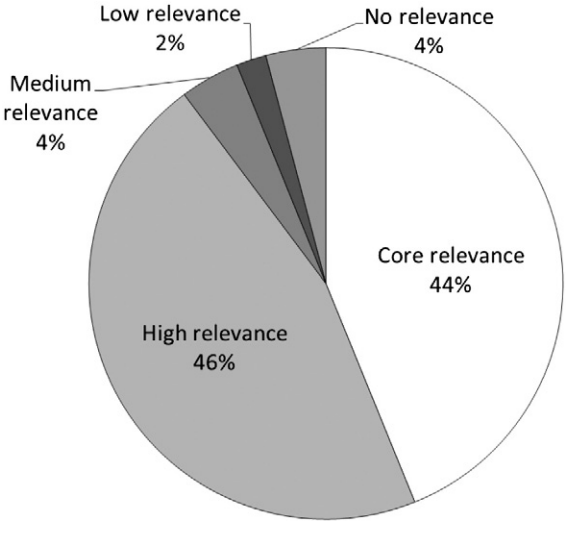

Fig. 5. The distribution of the economic relevance assessment of AgustaWestland's patent portfolio.

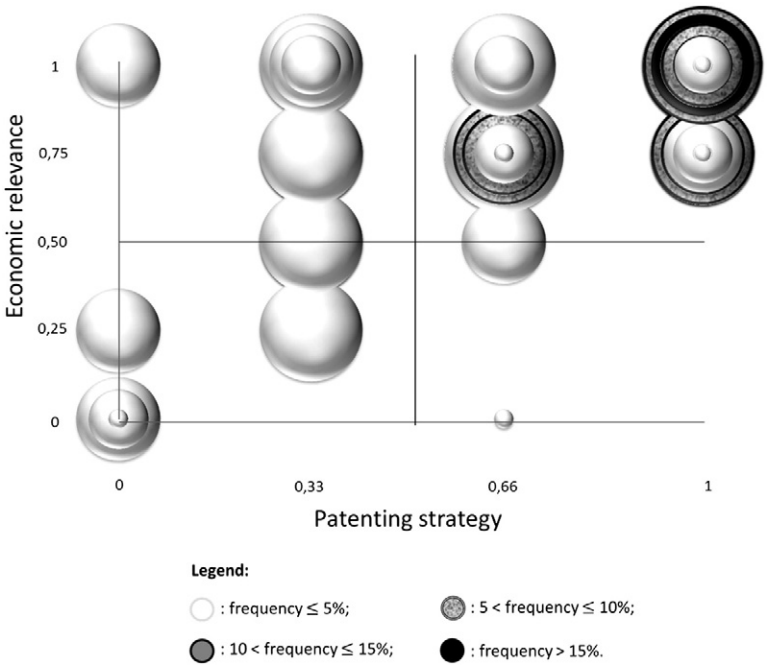

Fig. 6. AgustaWestland's patent portfolio analysis.

AW keeps its patent portfolio focused on strategic technologies and widely optimized as well on the basis of its technological specificity in the sector.

4.2.2. DRS Technologies' patent portfolio value

DRS patents in the electronics sector and some of its patents are also characterized by radical innovations. The patent portfolio of DRS is characterized by the values of the five indicators, as they appear in Table 5.

The indicator TS shows a value of 0.39. This value accounts for a very frequent circumstance which is verified within the electronics sector in recent times: the reconversion and growth of the security industry. In this environment, there is a strong acceleration in trying to find new utilizations of the so-called "dual use" technologies, such as military applications of civilian technologies and vice-versa. More specifically, the portfolio of DRS, mainly focused on "Basic electric elements" and "Measuring and testing" IPCs, is characterized by several utilizations which extend from basic electronics up to dual applications of the professional communications.

The indicator FCF shows a value of 0.07. This value issues from the high specificity of the technological activity of DRS that, despite the interest of operators from different sectors in DRS initiatives in electronics and adjacent fields, do not engender a high number of forward citations.

The indicator IS shows a value of 0.20. This value derives from the geographic coverage of the patent portfolio of DRS, as shown in Fig. 7. The rather low value depends on the fact that the greatest part of DRS business is centered on the unique national military customer and that, consequently, there is no need for DRS to protect its technologies against its potential competitors, France or Russia, for instance, but fundamentally only against those which have a significant commercial relevance, such as Canada, the UK, Australia, Germany and Brazil, being among the most important.

Both PS and ER values show the same value of 0.37. The results of the assessments of each patent of the portfolio are synthesized in Figs. 8 and 9 for PS and ER respectively.

The analysis of the structure of the patent portfolio of DRS shows that the portfolio is not optimized, as most of patents (more than 60%) are regarded "defensive" technologies or even "not essential" technologies. The cause of this fact is that DRS is a group gradually built up over the last 20 years through the mergers of more than 50 little and medium enterprises working in military and civilian sectors. DRS portfolio inherited many patents of the old technologies, significant to the source companies at the moment of the merger but now not important and not technologically considerable anymore. Quite simply, these no more strategic patents have not been removed from the portfolio.

Previous considerations are confirmed by the results of the ER value analysis. DRS patent portfolio shows more than 50% of patents which do not contribute anymore to the company's revenues ("low relevance" or "no relevance"). On the other hand, a remarkable percentage (around 18% with "medium relevance") of patents can be cashed in by licensing them out,

Table 5
The 5 indicators of DRS Technologies.

Indicators	Values for DRS
Technical scope (TS)	0.39
Forward citation frequency (FCF)	0.07
International scope (IS)	0.20
Patenting strategy (PS)	0.37
Economic relevance (ER)	0.37

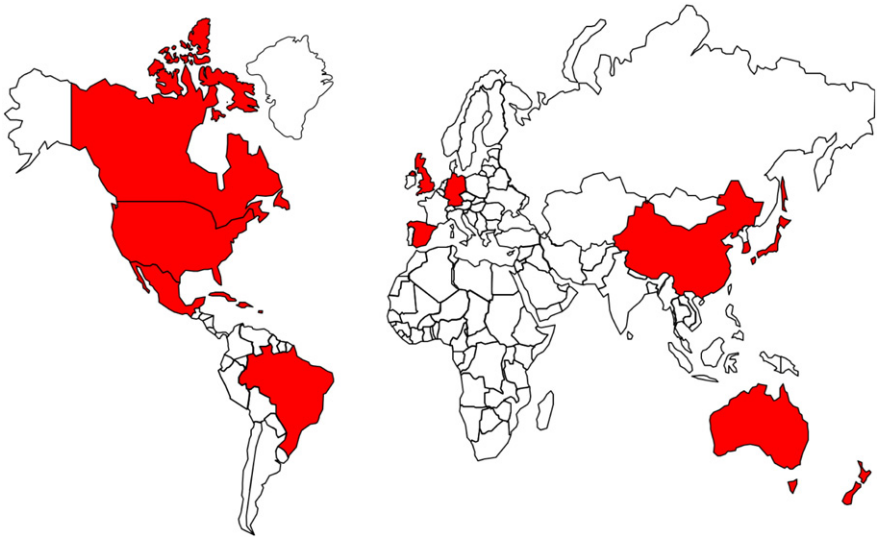

Fig. 7. The geographic coverage of DRS Technologies' patent portfolio.

or possibly put on those markets which are closely connected to the security sector for dual use purposes.

The joint analysis of DRS' patent portfolio has been carried on by combining the five criteria, as described in Section 3.6. In Fig. 10, as previously for AW, the position of DRS patents in the Cartesian system shows their PS and ER values; the size of the bubbles indicates their proportionality to the mean approximated values of TS, FCF and IS; the shades of gray relate to the number of patents which have the same coordinates of PS and ER and fall in the same interval of the mean values of TS, FCF and IS.

Fig. 10 shows that the bubbles which represent the patents lie along the diagonal which connects the two quadrants characterized by low values of PS and ER and high values of PS and ER. The position of bubbles in the low left quadrant (low values of ER and PS) means that these patents do not add value to the company's portfolio. The position of bubbles in the high right quadrant means that these patents have a medium-high value both of ER and PS and therefore they can be considered as valuable and very close to the core competence of the company. Moreover, certain bubbles lying below the main diagonal, despite their medium-high PS value, show the low profitability of these patents.

Proceeding with the analysis, it is possible to deduce that the majority of the bubbles which show the greater sizes lie along the diagonal. This suggests that for DRS patents there is not any correlation between their strategic–economic relevance and technologic–bibliometric one; indeed, patents with a poor strategic relevance are considered as important by the scientific and technologic communities and, vice-versa, patents with a very high strategic relevance receives poor attention.

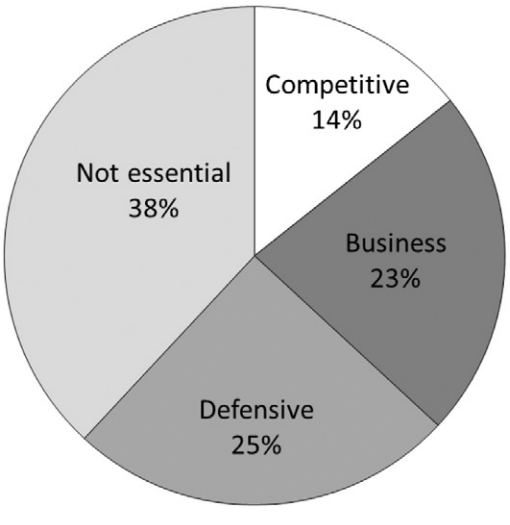

Fig. 8. The distribution of the patenting strategy assessment of DRS Technologies' patent portfolio.

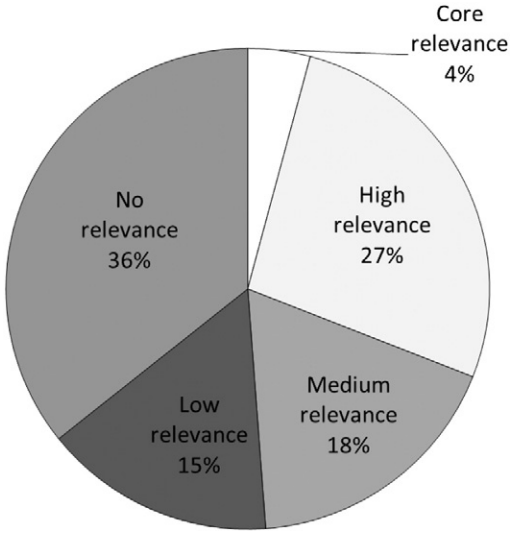

Fig. 9. The distribution of the economic relevance assessment of DRS Technologies' patent portfolio.

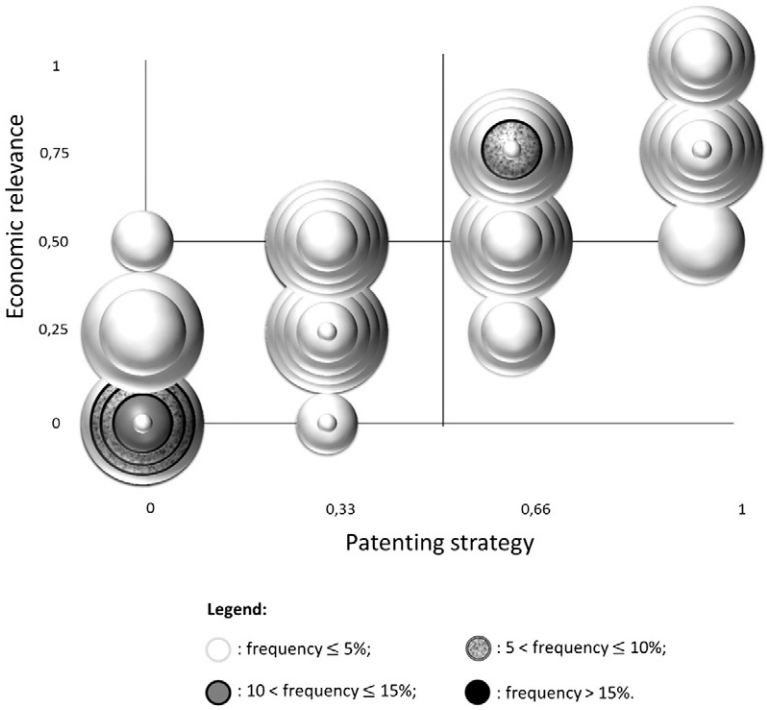

Fig. 10. DRS Technologies' patent portfolio analysis.

Lastly, from the shaded gray color of the bubbles (the number of patents) it is possible to deduce that the most of the patents, almost 65% of all patents of DRS, is positioned in that quadrant where both PS and ER have low-medium values. In particular, the gray bubbles which are characterized by the null values both of PS and ER represent about the 30% of all the patents. Oppositely, only a little more than 28% of patents are positioned in that quadrant where both PS and ER have medium-high values. If we consider the position, dimension, and number of patents as a whole, we can infer that DRS should single out those patents which are neither valuable nor strategic anymore in order to sell or license them on the appropriate markets and focus its technology-driven and market-oriented investments on those patents still profitable and considered as important not only within but also outside the company.

The analysis of the AW's patent portfolio shows that it contains a lot of patents which are growing up or arriving at their maturity, and a few patents which are not significant to the core business of the company anymore. This means that most of AW's technologies are still in use and that its highly profitable products are protected by patents and yield relevant revenues. On the contrary, the analysis of DRS's patent portfolio shows that it is characterized by a low economic contribution deriving from its technologies or patented products. In detail, it is possible to note that DRS's patent portfolio contains few patents which are grown up and several patents considered as not strategic anymore or, however, not relevant to the core technology of the company; therefore, these last should be sold or abandoned.

The analysis of the positions, dimensions, and number of patents shows the differences between the two companies and these are described by differences in strategic, competitive,

4.3. Discussion

In order to illustrate the results that we obtained about the strategic information and the composition of the two different patent portfolios, it is useful to display the standard temporal evolution that outlines patent portfolios (Fig. 11). At its initial step (I), a patent portfolio of a company is usually characterized by a high value of PS and a low value of ER. In the following step (II), the company begins to reap the benefits of its technological investment and the patent portfolio is characterized by a high value of PS and a high value of ER (top right). Finally (III), when the patent portfolio gets technologically old, it arrives at its maturity. These patents have completed their life cycle and are characterized by a low value of PS but a still adequate value of ER.

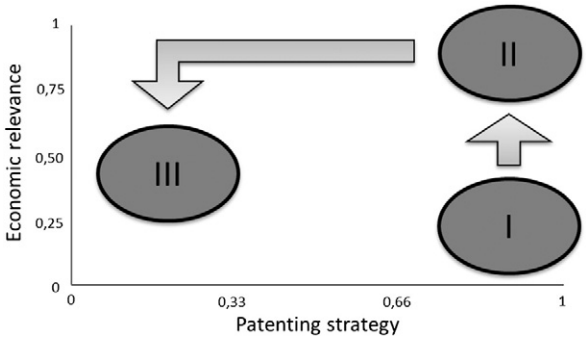

Fig. 11. The typical evolution of a patent portfolio.

technological, and market policies. The graphic analysis accounts for the value of the internal business perspective, shows the profitability of the company's patents, and helps visualize strategic information and managerial indication to assess and leverage the value of patent portfolio. We can observe that the results of portfolio analysis of AW and DRS vary in dependence of the optimization of patent management. The AW patent portfolio value, as it is inferred from the analysis carried on by the proposed framework, appears as satisfactory since its protected rights of the knowledge base are managed and valorized adequately. However, AW should encourage initiatives which could account for the reason of the inefficacy of those patents that in spite of their high-medium value of technologic–bibliometric features are considered as poorly relevant from a strategic point of view. For the patent portfolio value of DRS, the analysis recommends that some initiatives be undertaken in order to dismiss some technologically outdated patents or license the non-profitable patents on adjacent markets or try to access the secondary market of its supply chain as well.

5. Conclusions

This paper introduces a practical and replicable framework to support scholars and practitioners in leveraging the value creation process by deriving information from the patent portfolio analysis in order to undertake its strategic management. The framework is innovative in that it is able to combine and synthesize two essential factors of the value assessment of patent portfolios: the technologic–bibliometric information with the economic–strategic judgments.

Information data from five different patent features is combined by the framework, the first three of which are extracted from many patent databases and refer to the technologic and bibliometric feature of patents, while the second two are obtained by interviewing involved managers and refer to the managers' judgments about the strategic and economic relevance of patents.

Two types of analyses can be accomplished by this framework: an assessment of the value of patent portfolios in companies' context both if a single portfolio and a single patent are considered and a graphic analysis, which allows to extract the information, necessary to manage patents by means of technological and strategic actions on the patents. By merging these two capabilities it is possible to assess both the appropriateness of the patent portfolio and the suitableness of the measures verified in order to aim at the maximum exploitation of that portfolio.

We applied the framework to two companies, the former having its main business in the field of helicopter design and manufacturing, the latter being the leading supplier of integrated products, services and support to military forces, intelligence agencies and prime contractors worldwide. The application showed that the framework is capable of providing a strategic analysis of the patent portfolio of one or more companies and synthetizing and equalizing the number of the acquired information into a single value that can be used to verify their optimization.

From this research it is expected that more in-depth explorations can initiate toward different environments of management application. Future developments of this paper could be directed to track the temporal evolution of the patent portfolio of a specific company, as well as to carry out a sectorial analysis by comparing the patent portfolios of companies, which work in the same sector. In addition to this, it would be fruitful to broaden the analysis of the assessment of the strategic–economic features by using the fuzzy logic methodology. Finally, a future further advancement of the present analysis could be that of exploring the behavior of the three technologic–bibliometric criteria and the dynamics of the value of the third dimension in the patent portfolio analysis graphic instrument, when assigning different weights. The adoption of weights different from those sized in the present paper could be adjusted to meet the specific demands of strategic technologic planning in particular contexts.

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