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Managing firm patents: A bibliometric investigation into the state of the art

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ABSTRACT

In today's economy, patent management has assumed particular relevance within firm strategy. However, the academic literature on this topic has never been subjected to a systematic review. In order to do so, we adopted two bibliometric techniques (citation analysis and bibliographic coupling). Our analyses allowed us to identify three main research subfields within patent management literature: "patent value", "strategic exploitation of patent value" and "technological and competitive landscape". In light of the description and the discussion of the meaning of each of them, we suggest some research lines that could benefit from deeper investigation and provide managerial implications and recommendations.

1. Introduction

More and more, in today's knowledge economy, intangible assets represent a significant portion of a firm value (Reitzig, 2004b). In fact, in a context where the global competition has shifted from the control of the markets and raw materials to the development and ownership of innovative ideas (Miles, 2007), intellectual property (IP), that accounts for a large part of intangible resources, is increasingly recognized as an important driver to gain and sustain firm competitive advantage (Rose et al., 2007).

All those changes have also been reflected in the evolution of the use of patents during time. While initially their purpose was to be merely a legal temporary means of protection of firm innovations, nowadays their use is more complex and broad since they are intended also as instruments to secure the applicant's own future technological space against competitors or as obstacles to competitors' future technological activities (e.g., Blind et al., 2009), especially when patented technologies are essential to comply with an industry standard (Berger et al., 2012; Delcamp and Leiponen, 2014). In addition, patents are seen as financial assets, since they can generate revenues from licenses and attract external funds (e.g., Rose et al., 2007; Blind et al., 2009), collaboration (e.g., Bader, 2008; Holgersson, 2013) and negotiation assets (e.g., Carlsson et al., 2008; Holgersson, 2013), source of information about technological landscape and competitors' research and development (R&D) activities (e.g. Ernst, 1998) and important means to shape industry structure through standards setting or the formation of patent thickets (e.g., Somaya, 2012; Tamura, 2012).

Consequently, the exploitation and strategic use of patents seem to be a crucial and challenging issue, thus their management should not be left only to legal attorneys or R&D staff, but considered as an element to include in the overall corporate and business strategy (Fisher and Oberholzer-Gee, 2013).

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However, obtaining and maintaining patents represent a considerable investment. Just to provide an example, filing a patent application and then, after grant, maintaining it in force in all the European countries might cost about €168.000 (De, 2014).

Therefore, even before defining an exploitation strategy, a firm should make rational and conscious decisions about which are the inventions that, if patented, have more potential for contributing to its capabilities and competitiveness in the marketplace. Similarly, a firm should also decide which of its patents, after time, are still worth the payment of the maintenance fees. Thus, patent management includes all the activities mentioned above and it can be seen as a process starting from the "patent planning" (i.e., which inventions are worth being patented) and ending with the "patent evaluation" (i.e., which patents are worth being maintained). Accordingly, the process of patent management should unfold the following stages: upon the generation of a new idea and its realization process, it should be decided whether to apply or not for patent protection for the developed invention and an appropriate patent exploitation strategy should be chosen (Sullivan, 1998; Gassmann et al., 2012); finally, after grant, it should be required to routinely assess the strategic and economic worth of the patent in order to find out whether it is still bringing value to the firm (Sullivan, 1998; Rivette and Kline, 2000; Gassmann et al., 2012).

Despite early research on patents was mostly conducted under a legal or economic perspective, in more recent years, the number of articles dealing with a strategic and management point of view has been gathering pace (Candelin-Palmqvist et al., 2012; Somaya, 2012); however, until now a systematic literature review on patent management has not be undertaken. We think that the less the diverse contributions on the theme are systematized, the greater the risk of developing a quite fragmented literature, and, as a consequence, the higher the difficulty in taking a step forward on private firm patent management theory becomes. Indeed, outlining the key findings of the literature on the theme, as well as identifying gaps and future lines of inquiry, may represent an added value for academics.

Moreover, synthetizing the current knowledge on patent management might provide practitioners with new insights into how an attentive and discliplined patent management process allows managers to determine the course of action which is more advantageous for the firm. In fact, an effective patent management process could lead to different benefits, such as: leveraging patent's inherent value through the definition of an appropriate exploitation strategy, saving money, balancing the cost associated to filing and maintaining patents with their ability to provide profits to the firm.

Thus, the purpose of this paper is to review the literature about firm patent management, identifying and analysing its main subfields and suggesting potential directions for future research on the topic. To this end, we adopt a bibliometric approach that, thanks to mathematical and statistical analyses of bibliographic data, allows us to assess the cohesiveness within the research community and map the intellectual structure of a certain scientific field. Results of bibliometric analyses make it possible not only to summarise the current knowledge about the field but also to outline research areas that require further investigation and to derive managerial implications.

2. Methodology

The procedure adopted to conduct the analyses is made up by three subsequent steps. Firstly, we selected the articles that represent the main contributions to the field of "patent management", and thus constituting its intellectual core. Using Sitkis and Ucinet software, the second step consisted in the analysis of citations among these documents to test whether they form a coherent body of literature. Finally, we performed a bibliographic coupling analysis, followed by factor analysis, in order to classify the main articles into subgroups, which represent the major branches of the "patent management" theme.

2.1. Paper selection and identification of the intellectual core

Since the rigorous identification of the intellectual core represents the first critical step to uncover and map the underlying intellectual structure of a research field (McCain, 1990), our sampling process was based only on papers published in academic journals. In fact, journal articles compared to other form of documents, such as doctoral thesis or books, are considered as more "certified knowledge" since they had been reviewed and approved by fellow researchers, and their use of citations is a standard practice that enhances the reliability of results (Ramos-Rodríguez and Ruíz-Navarro, 2004).

In order to select the papers, we started with the identification of the keywords according to the definition of "patent management" and distinguished them into two subsets (Group 1: manag*; strateg*; plan*; assess*; valu*; evalu*; Group 2: patent*; "IP"; "IPR"; "Intellectual property"); then; combining each keyword from the first set with each keyword of the second one; 24 different queries were obtained. Applying these research criteria to the title of the papers contained in the ISI Web of Science database; the number of articles retrieved; at the end of September 2014; is 229 (duplicates excluded).

This initial dataset was refined at later steps in order to exclude those papers that are not directly focused on the topic under investigation. To avoid subjectivity in the refinement process, two researchers worked independently, reading the abstract of each of the 229 papers and excluding ones that:

- adopt a macroeconomic, policy or legal perspective;
- regard patent activity carried out by public research centres, universities or single inventors;
- concern other forms of Intellectual Property Rights (such as trademarks, copyright, . . .)

– deal with patent trolls or piracy.

To test the coherency of the refinement process made up independently by the two researchers, we conducted a reliability check on a subsample of the papers, finding that more than 90 per cent of the exclusions were consistent and that the disagreements were due to some minor different nuances in interpretation, that were resolved after discussion and careful review of the entire article.

The final set of papers pertinent to the topic of "patent management" was restricted to 103 contributions, which can be considered as the intellectual core of the field to be analysed in the subsequent step.

2.2. Citation analysis

Citation analysis is aimed at studying networks of citations, which represent the knowledge flows between documents within a research field. Observing, on the basis of mutual citations, how much the papers of the sample are interconnected, this technique allows researchers to assess the level of cohesiveness in a quantitative way.

In order to carry out the analysis we firstly constructed a database that linked all the papers in our sample to the references they cited, using the software Sitkis. Then, two measures of centrality were computed: (1) "received citations" (the number of times a paper has been cited by one or more of the other articles in sample) and (2) "sent citations" (the number of times a certain paper cited one or more of the other articles in the sample).

2.3. Identification of subgroups through bibliographic coupling and factor analysis

In the third phase of our analysis, the proximity between the core papers was firstly measured using the bibliographic coupling approach, then, through factor analysis, the number of factors that represent the subfields of the "patent management" literature was identified.

Bibliographic coupling, together with co-citation analysis, represent two of the main bibliographic techniques to quantitatively assess the relatedness between subject matter of two works. Bibliographic coupling method is grounded on the assumption that two articles with numerous references in common probably deal with similar research fields (Kessler, 1963). Thus, two documents are coupled if they cite the same third one and bibliographic coupling strength between two papers is measured as the number of shared citations by both papers (Kessler, 1963). On the other hand, co-citation analysis assumes that papers reporting on the similar topics are likely to be cited together in the subsequent literature (Small, 1973). So, two papers are co-cited if they appear in the same bibliographic list (see Fig. 1).

However, as suggested by numerous authors (e.g., Gregoire et al., 2006; Vogel and Güttel, 2013) the former method is more suitable to study recent literature fields and current research topics and it increases result accuracy (Boyack and Klavans, 2010). Thus, due to the characteristics of our sample (described in paragraph 3.1), we chose bibliographic coupling instead of co-citation analysis.

We began the procedure to carry out bibliographic coupling analysis constructing a mathematical representation of the links between core papers and their references, through the so called "paper-reference matrix". Matrix elements are equal to 1, if the paper (in column) cites the correspondent reference (in row), otherwise 0.

Starting from the latter, the "bibliographic coupling" matrix was then compiled. The "bibliographic coupling matrix" is a symmetric matrix, with rows and columns listing all papers in the sample of analysis and elements representing the number of common references between each pair of them (i.e., "bibliometric coupling strength"). On this basis, the similarity between each pair of articles was computed converting the "bibliometric coupling matrix" into a Pearson's correlation coefficients one. They are preferable to frequencies since they make it possible to standardize data and reduce the number of zeros, thus providing a better basis for subsequent statistical analyses (Rowlands, 1999).

Finally, to analyse the data, we used the correlation matrix as input for different multivariate techniques. In particular, we relied upon factor analysis to explore the underlying structure of interconnections among the papers in the sample under investigation. Based on different degrees of relatedness between papers, factor analysis allowed us to classify them into

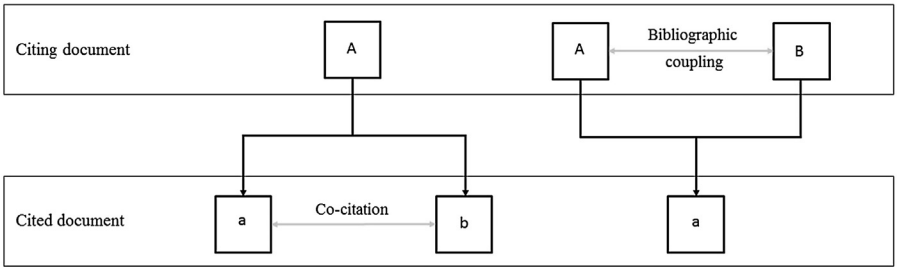

Fig. 1. Bibliographic coupling vs co-citation analysis (Voegel and Güttel, 2013).

homogeneous sets called "factors" (Di Stefano et al., 2010). Since factors can be seen as specific subfields or intellectual subthemes, their identification permitted us to detect the structure of the literature field.

The method of Principal Component Analysis (PCA) was adopted to extract the factors, whose number was defined using the Kaiser's criterion (Kaiser, 1960). Factor loadings, which represent the correlation, or the degree of affinity, between a given article and the correspondent factor, lower (in absolute value) than 0.4 were dropped. Consistent with prior studies (Nosella et al., 2012), whenever a paper loaded positively on more than one factors, we complied the following rules in order to attribute them to the most appropriate factor. If one of the loadings was (in absolute value) equal to 0.7 or greater and the other loadings was lower than 0.5 (in absolute value), it means that the paper was likely to be useful in interpreting the factor on which it loaded more and consequently it was included in that factor. On the other hand, if the loadings (in absolute value) ranged from 0.5 to 0.7, the paper, despite representing a bridge between different topics, could not be assigned for certainty to one factor, and, thus, it was excluded from the interpretations.

3. Results

The following paragraphs summarise and discuss the outcomes of the analyses performed.

3.1. Sample description

As depicted in Fig. 2, the number of papers concerning the management of patents has significantly grown during time. Notably, articles published in the last decade represent more than 70% of the sample under investigation, suggesting the increasing importance of the theme and growing research opportunities.

In addition, core articles are published in different international journals, with a prevalence of journals specialized in technology and innovation management, which is the outlet of more than half of the articles (Fig. 3).

3.2. Findings from citation analysis

In order to have a clearer visualisation of the degree of cohesiveness among papers belonging to the intellectual core, results of citation analysis are represented graphically in the following figure (Fig. 4).

Each node of the graph symbolizes a paper that cites or is cited by at least one of the other document of the sample. Coloured shapes are used in order to distinguish nodes with different features: red triangles are chosen for those articles that both cite and are cited by other source papers, blue squares designate the articles that only cite one or more papers in the sample, while green circles represent the articles that are only cited by one or more documents of the sample.

Although 28 papers of the intellectual core do not cite any other document or have not been cited by any other document in the sample, when looking at the network, it is possible to notice a strong interconnection especially among the articles that are located within the dotted line. In particular, as shown in the subsequent table (Table 1), five papers (Trajtenberg, 1990; Hall et al., 2005; Harhoff et al., 2003; Harhoff et al., 1999; Lanjouw et al., 1998) received and sent more than the 25% of the total citations (313 citations) exchanged within the entire sample. In addition, these five articles can be considered as "key influencer" for "patent management" literature, since they have attracted about the 45% of citations sent by the articles in the sample (169 citations). All the five papers contained in this short list mainly discuss and test patent value antecedents.

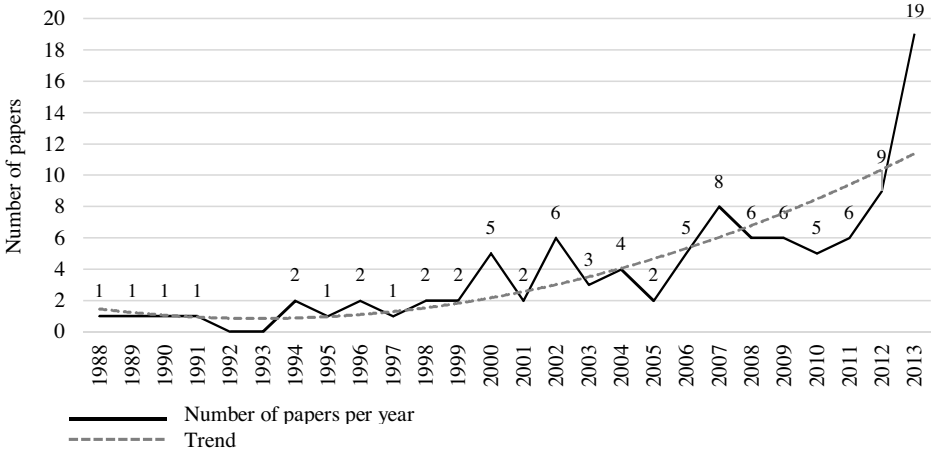

Fig. 2. Yearly distribution of papers in the sample (data relative to the number of papers published in 2014 are omitted, since our analysis does not cover the entire year).

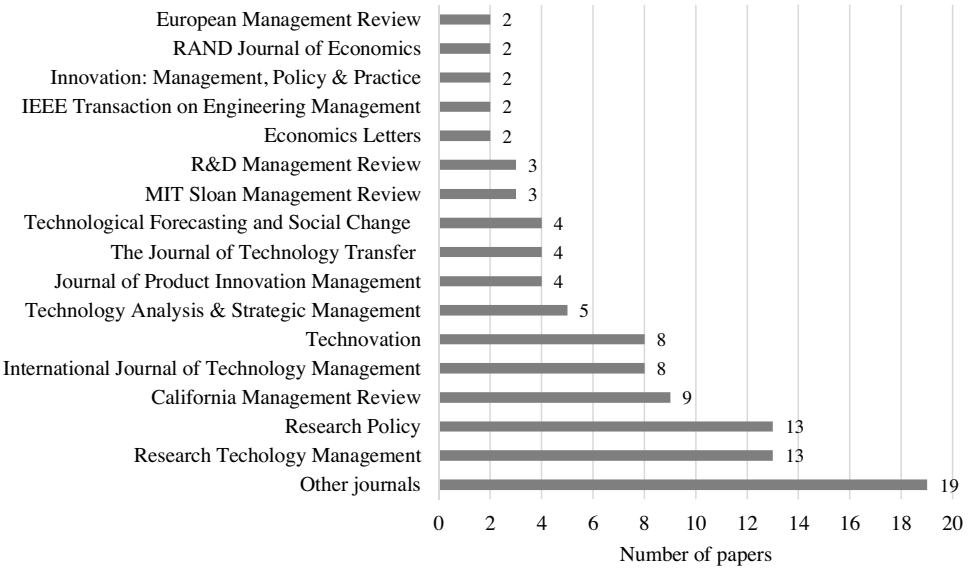

Fig. 3. Journal distribution of the core papers.

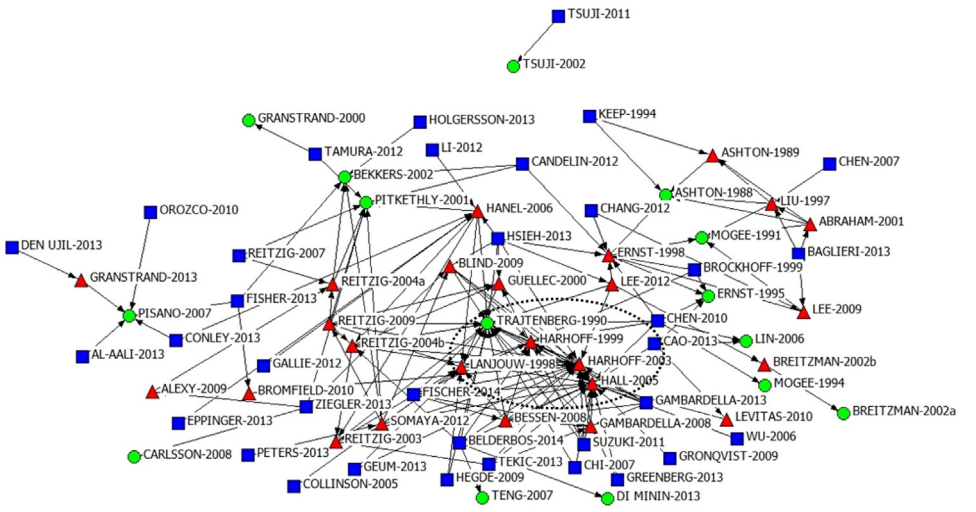

Fig. 4. Network of citations between the papers in the intellectual core of "patent management" literature.

Table 1
Most interconnected papers within the intellectual core of the literature field about "patent management".

	Sent Citations	Received Citations	Total Citations	Percentage Received Citation on Sample Received Citations	Percentage Total Citation on Sample Total Citations
Trajtenberg (1990)	0	21	21	12.43% (21/169)	6.71% (21/313)
Hall et al. (2005)	1	20	21	11.83% (20/169)	6.71% (21/313)
Harhoffet al. (2003)	3	15	18	8.88% (15/169)	5.75% (18/313)
Harhoffet al. (1999)	2	10	12	5.92% (10/169)	3.83% (12/313)
Lanjouw et al. (1998)	0	11	11	6.51% (11/169)	3.51% (11/313)
Sum				**45.56%**	**26.51%**

3.3. Findings from bibliographic coupling and factor analysis

With the aim of uncovering the subfields that constitute the structure of "patent management" literature, we performed a bibliographic coupling analysis followed by factor analysis.

As shown in Table 2 (see Appendix A), factor analysis provided a three-factor model.

Results of factor analysis are also mapped in the following figure (Fig. 5), that highlights the structure of the literature field under examination. It is characterized by three distinct factors: yellow diamonds represent articles belonging to the first factor, red triangles are the papers assigned to the second factor and green squares are the articles included into the third factor. In the picture, grey dots represent papers that loading on more than one factor could not be attributed univocally to one of them.

After reading and analysing all the papers and according to their topic, we label the identified factors as:

- Factor 1: "Patent value", which includes 25 papers
- Factor 2: "Strategic exploitation of patent value", which comprises 26 papers
- Factor 3: "Technology and competitive landscape", made up of 10 papers.

Each factor is described and explained in the following paragraphs.

3.3.1. Patent value

During the last two decades, economists and management scholars have increasingly recognized that assessing patent value is, at the same time, an important (Reitzig, 2003; Bessen, 2008; Gambardella, 2013) but difficult task (Harhoff et al., 2003). Addressing this issue, papers belonging to the first factor mainly discuss and test which antecedents might influence the value of a single patent.

Patent value is measured differently among the authors: some studies refer to experts' judgements, like managers or inventors (Harhoff et al., 1999; Harhoff et al., 2003; Reitzig, 2003; Gambardella et al., 2008; Suzuki, 2011); while, other authors rely on more objective observations such as patent market value (Fischer and Leidnger, 2014), consumer and producer welfare (Trajtenberg, 1990), the probability that an application is granted (Guellec and de la Potterie, 2000), the likelihood to incur in opposition (Reitzig, 2004a), the times or the probability a patent is renewed or the probability of renewal (Bessen, 2008; Grönqvist, 2009; Hedge and Sampat, 2009) (see second box in Fig. 6).

A huge variety of patent value antecedents, related to patent own characteristics, has been studied as well. Generally they are expressed in form of quantitative indicators, but in some studies they are also represented through qualitative variables to be rated by experts on a Likert's scale (Reitzig, 2003; Suzuki, 2011; Tekic and Kukolj, 2013) (see first box in Fig. 6).

As far as the mostly discussed patent value antecedents are concerned, many authors investigate patent "backward citations" and "forward citations", number of claims, number of IPC classes, patent family size and applicant type.

A patent can both cite and be cited by other documents. On the one hand, the list of documents cited by a patent form its "backward citations", which can be either other patents or scientific publications. Backward citations represent the extent to which a patent is built upon existing prior art (Fischer and Leidinger, 2014), but also the patent technical novelty (Reitzig, 2003) and scope (Harhoff et al., 2003). On the other hand, the list of documents citing a patent is defined as patent "forward

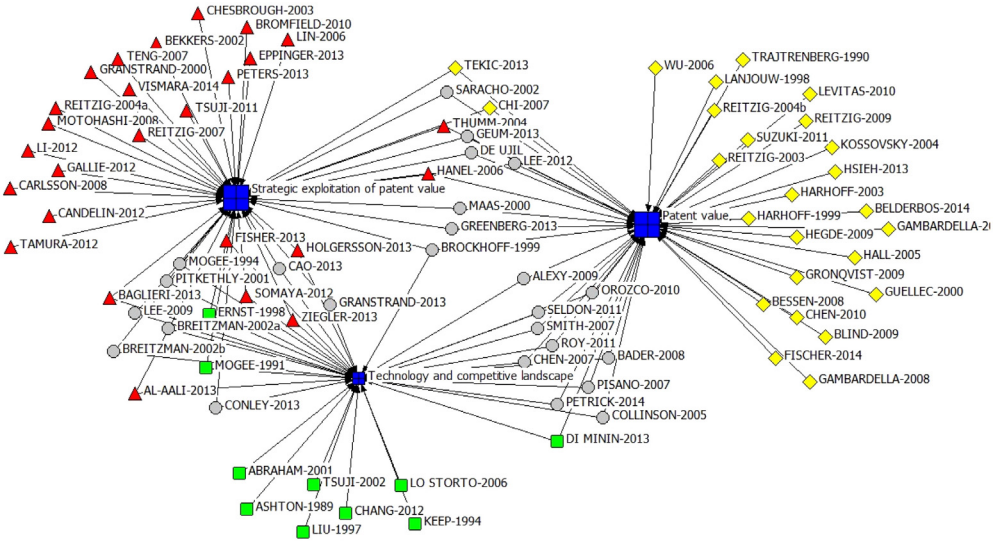

Fig. 5. Bibliographic coupling network of the papers in the intellectual core of "patent management" literature.

Patent value determinants	
- Backward citations	Harhoff *et al*., 2003; Reitzig, 2004a; Bessen, 2008; Gambardella *et al*., 2008; Suzuki, 2011; Fischer and Leidinger 2014
- Forward citations	Harhoff *et* al., 1999; Harhoff *et al*., 2003; Hall *et al*., 2005; Bessen, 2008; Gambardella *et al*., 2008; Hedge and Sampat, 2009; Chen and Chang, 2010; Suzuki, 2011; Fischer and Leidinger, 2014
- Patent family size	Guellec and de la Potterie, 2000; Harhoff *et al*., 2003; Reitzig, 2004; Gambardella *et al*., 2008; Fischer and Leidinger, 2014
- Number of claims	Bessen, 2008; Gambardella *et al*., 2008; Suzuki, 2011; Fischer and Leidinger, 2014
- Number of IPC Classes	Guellec and de la Potterie, 2000; Harhoff *et al*., 2003; Reitzig, 2004; Fischer and Leidinger, 2014

Patent value	
- Experts' judgements	Harhoff *et al*., 1999; Harhoff *et al*., 2003; Reitzig, 2003; Gambardella *et al*., 2008; Suzuki, 2011
- Patent market value	Tekic and Kukolj, 2013; Fischer & Leidnger, 2014
- Consumer and producer welfare	Trajtenberg, 1990
- Probability of grant	Guellec and de la Potterie, 2000
- Probability of opposition	Reitzig, 2004a
- N° or probability of renewals	Bessen, 2008; Grönqvist, 2009; Hedge and Sampat, 2009

Firm economic performance	
- Firm market value	Hall *et al*., 2005; Chen and Chang, 2010

Fig. 6. Structure of the factor "Patent Value". (For simplicity, in the first box only the most frequently studied patent value antecedents are reported).

citations" that can be made by the examiner, the same applicant or another patentee. Forward citations are considered as an indicator of technological importance: the higher the number of citations to a patent, the higher its contribution to the development of new inventions (Fischer and Leidinger, 2014). Authors who studied the effect of these two variables (e.g., Harhoff et al., 2003; Bessen, 2008) found that both backward and forward citations have a positive impact on patent value. In particular, backward citations to patent literature are more informative than ones to scientific literature (Harhoff et al., 2003; Reitzig, 2004a) and examiner forward citations are more informative compared to forward citations made by other patentees (Hegde and Sampat, 2009).

The number of claims and the number of IPC classes are both used as indicators of patent "technological breadth". The former, beyond representing patent inventive step (Reitzig, 2004a), also expresses its legal sustainability (Fischer and Leidinger, 2014). The latter specifically reflects the technological diversity of the numerous ideas that made up the protected invention (Guellec and de la Potteire, 2000). While all studies (Bessen, 2008; Gambardella et al., 2008; Fischer and Leidinger, 2014) confirm that the number of claims is positively associated to patent value, results about the relationship between the number of IPC classes and patent value are conflicting (e.g., Guellec and de la Potterie, 2000; Reitzig, 2004a; Fischer and Leidnger, 2014).

Family size is the number of jurisdictions where patent protection has been extended, thus it is considered as an indicator for patent international scope of protection. It has been proved that patent family size is positively associated to patent value (Harhoff et al., 2003; Reitzig, 2004a; Gambardella et al., 2008; Fischer and Leidinger, 2014), but Guellec and de la Potterie (2000) find that this relationship is not linear.

Finally, it is found that also applicant type influences patent value: patents issued to firms are more valuable than the ones owned by private persons or no-profit organizations (Bessen, 2008; Grönqvist, 2009).

Among the papers belonging to this factor, two also test whether antecedents of patent value have an impact on firm performance (see third box in Fig. 6). On the one hand, Hall et al. (2005) prove that a firm market value is significantly boosted by the number of citations its patents received, while, on the other hand, results of Chen and Chang (2010) show that citations received and firm market value have an inverted U-shaped relation.

Fig. 6 clarifies in detail the structure of this factor.

3.3.2. Strategic exploitation of patent value

Beyond providing legal protection, patents can be exploited by their holders in a variety of ways. Papers grouped in this factor mainly discuss how managers can extract value from their patents.

On the one hand, patents can be used within the boundaries of the assignee firm in order to exercise market power. When internally employed to protect products or processes, patents prevent imitation (e.g., Ziegler et al., 2013) and allow to benefit from a short-term technological lead advantage over competitors (Reitzig, 2004b; Fischer and Oberholzer-Gee, 2013; Holgersson, 2013), which can be turned into higher prices (Hanel, 2006). A firm might also use its patents in order to block competitor R&D efforts (Thumm, 2004; Somaya, 2012; Holgersson, 2013) or secure its future freedom to operate, develop and commercialize its technologies without being hindered by third party patents (Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Ziegler et al., 2013) or getting sued (Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013).

Great attention should be paid to the possibility of combining patents with other form of IP, such as trade secrets (Carlsson et al., 2008; Al-Ali and Teece, 2013) or trademarks (Reitzig, 2004b; Carlsson et al., 2008; Al-Ali and Teece, 2013), in order to enhance patent protection. Trade secrets are not only an alternative way to protect firm intellectual assets: secrecy might be used to cover those specific aspects of know-how that, otherwise could not be protected by patents, are necessary complements to operate the technology described and protected by the patent (Al-Ali and Teece, 2013). Before expiration, managers might try to communicate patent technical advantages through trademarks, protecting and transferring to the brand the reputational aspects stemming from the technical benefits (Reitzig, 2004b; Al-Ali and Teece, 2013). In fact, patents might also represent a mean to build and improve a firm reputation of being innovative (Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Holgersson, 2013) as well as to strengthen its position in negotiations (Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Holgersson, 2013) or facilitate the establishment of collaborations with third parties (Thumm, 2004; Reitzig, 2004b; Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Holgersson, 2013; Ziegler et al., 2013). Moreover, by virtue of its technological reputation a firm might also attract and retain public or private investors (Thumm, 2004; Lin et al., 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberhlzer-Gee, 2013; Vismara, 2014) and attract, motivate, and reward R&D personnel (Hanel, 2006; Somaya, 2012).

In addition, patents can also be exploited in order to shape market industry. Patents might be turned into barriers to control or prevent market entry (Reitzig, 2004b; Thumm, 2004; Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberhlzer-Gee, 2013; Ziegler et al., 2013), securing protection on industry standards upon which all products adhering to the standard must be developed and manufactured (Bekkers et al., 2002; Reitzig, 2004b; Somaya, 2012; Tamura, 2012; Al-Ali and Teece, 2013; Holgersson, 2013) or building patent fences or thickets (Reitzig, 2004b; Thumm, 2004; Hanel, 2006; Somaya, 2012).

Table 3 shows the internal exploitation strategies and the authors who cite them.

On the other hand, patents can be seen by their holder as tradable asset that are suitable for being externalized to another independent organization upon monetary or non-monetary rewards (Ziegler et al., 2013). Thus, selling, out-licensing, cross-licensing or donating represent patent external exploitation strategic choices (see Table 4). Selling (Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Ziegler et al., 2013) or donating (Carlsson et al., 2008; Fisher and Oberholzer-Gee, 2013) a patent entails ceding its ownership to a third party, while licensing-out (Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Motohashi, 2008; Somaya, 2012; Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and

Table 3
Patent exploitation strategies within the boundaries of the assignee firm.

	Authors
Protecting against imitation of competitors	Thumm, 2004; Hanel, 2006; Teng, 2007; Motohashi, 2008; Lin et al., 2006; Tsuji, 2011; Gallié and Legros, 2012; Li and Ni, 2012; Somaya, 2012; Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Holgersson, 2013; Peters et al., 2013; Ziegler et al., 2013
Creating a short-term technological lead advantage	Reitzig, 2004b; Fischer and Oberholzer-Gee, 2013; Holgersson, 2013
Blocking competitor R&D efforts	Thumm, 2004; Somaya, 2012; Holgersson, 2013
Securing future freedom to operate, develop and commercialize firm technologies	Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Ziegler et al., 2013
Preventing lawsuits	Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013
Combining different form of IP	Reitzig, 2004b; Carlsson et al., 2008; Al-Ali and Teece, 2013
Improving firm technological reputation	Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Holgersson, 2013
Strengthening negotiation position	Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Holgersson, 2013
Establishing of collaborations	Thumm, 2004; Reitzig, 2004b; Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Holgersson, 2013; Ziegler et al., 2013
Attracting of private or public founds	Thumm, 2004; Lin et al., 2006; Carlsson et al., 2008; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberhlzer-Gee, 2013; Vismara 2014
Attracting, motivating, and rewarding R&D personnel	Hanel, 2006; Somaya, 2012
Controlling or preventing market entry	Reitzig, 2004b; Thumm, 2004; Hanel, 2006; Somaya, 2012; Eppinger and Vladova, 2013; Fisher and Oberhlzer-Gee, 2013; Ziegler et al., 2013
Establishing industry standards	Bekkers et al., 2002; Reitzig, 2004b; Somaya, 2012; Tamura, 2012; Al-Ali and Teece, 2013; Holgersson, 2013
Building patents thickets	Reitzig, 2004b; Thumm, 2004; Hanel, 2006; Somaya, 2012

Table 4
Patent exploitation strategies external to the boundaries of the assignee firm.

	Authors
Selling	Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Ziegler et al., 2013
Donation	Carlsson et al., 2008; Fisher and Oberholzer-Gee, 2013
License-out	Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Motohashi, 2008; Somaya, 2012; Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Holgersson, 2013; Ziegler et al., 2013
Cross-license	Thumm, 2004; Reitzig, 2004b; Hanel, 2006; Carlsson et al., 2008; Motohashi, 2008; Somaya, 2012; Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Fisher and Oberholzer-Gee, 2013; Holgersson, 2013; Ziegler et al., 2013

Oberholzer-Gee, 2013; Holgersson, 2013; Ziegler et al., 2013) allows the innovator to retain the ownership and extend to others the rights to use the invention protected. When patented technologies are embedded in many players' products, their license can be mutually exchanged, i.e., cross-licensed, between those actors (Reitzig, 2004b; Thumm, 2004; Hanel, 2006; Carlsson et al., 2008; Motohashi, 2008; Somaya, 2012; Al-Ali and Teece, 2013; Eppinger and Vladova, 2013; Holgersson, 2013; Ziegler et al., 2013).

As just described, different strategies can be adopted in order to maximize returns from owned patents. Strategic choices are influenced by different factors, such as technology kind ("complex" vs "discrete" technologies) (Hanel, 2006), industry structure (Motohashi, 2008), or firm size (Holgersson, 2013). In this respect, since small and medium enterprises (SMEs) are increasingly recognized as important innovators (Eppinger and Vladova, 2013), some scholars focus their attention on understanding this issue in SME context.

In comparison to large companies, SMEs face human and financial resource constraints that limit their patent activity. It is highlighted that SME managers generally do not define a clear patent strategy and lack of competences and awareness about different exploitation strategies, such as commercialization or licensing out, that would allow to generate rents from patents (Eppinger and Vladova, 2013; Holgersson, 2013).

Also for large corporations, manager commitment and attention towards IP issues, both at the business unit level and top level, deeply affect patent exploitation strategy performance (Reitzig, 2007). In fact, scholars emphasise that defining an effective patent strategy, in-line with the overall business strategy, requires expertise and collaboration between different firm departments (e.g., Carlsson et al., 2008; Fisher and Oberholzer-Gee, 2013).

Further complexity is due to the fact that it is not possible to identify one optimal strategy to deal with patent exploitation, thus firms have to shape their own approach for each single patent (Reitzig, 2007).

3.3.3. Technology and competitive landscape

According to the World Intellectual Property Organization (WIPO) more than 90% of the world's innovations are reported in patent documents (Liu and Shyu, 1997). Thus, patent data, providing information with comprehensive coverage of technologies and countries, are frequently used as "technological indicators" (Mogee, 1991). However, the simple count of patent applications or grants might provide insufficient or misleading information (Mogee, 1991) to firms, which, in order to respond to the challenges of the actual economic context, are increasingly interested in gaining insight into technological and competitive landscapes.

On these bases, papers grouped in this factor develop methods and techniques aimed to deeply analysing patent data in order to track technological trends, collect meaningful information about competitors' R&D activity, identify and evaluate potential partners, thus supporting technology management and planning.

To outline the evolution of a certain technological area, Mogee (1991) and Liu and Shyu (1997) suggest studying the relationship between assignee concentration and patent activity of a technological field in order to observe which phase of life cycle the technology currently is. Furthermore, technology development can be assessed comparing the long and short-term growth in terms of yearly patent application filed (Ernst, 1998) or tracking the path of citations between subsequent patents (Liu and Shyu, 1997).

Together with technological landscape, patent data can also be used in order to gain insights into competitors' patent activity: competitors patent portfolio strengths and weaknesses are mainly drawn from the assessment of its overall value, measured through indicators such as the number of citations received (e.g., Mogee, 1991; Liu and Shyu, 1997; Ernst, 1998), patent family size (Mogee, 1991) and patent geographical distribution (Mogee, 1991; Ernst, 1998), share of applications vs granted or valid patents (Ernst, 1998).

Analysing the competitive environment, a firm can also benchmark the value of its patent portfolio against the competitors' one (Keep et al., 1994), study the products and processes that competitors are planning to introduce into a certain market (Abraham and Moitra, 2001), or find out technological complementarity and interdependence between different firms and thus allowing to identify potential R&D collaborators (Chang, 2012).

In addition, more sophisticated patent analysis methods to reveal intelligence about competitors' innovative behaviour are proposed. Drawing upon different kind of patent data, those analyses provide insights into competitors' organization and management of their new product development process (Tsuji, 2002) or ability to create innovation improving product components or recombining existing ones (Lo Storto, 2006).

Most of the contributions in this set suggests that all these analyses should be repeated during time in order to promptly detect technological changes or competitive threats (e.g. Liu and Shyu, 1997). Furthermore, analyses should be performed by experts, whose knowledge and judgment are fundamental to improve result accuracy and reliability (Mogee, 1991).

4. Discussion and conclusions

Acknowledging the importance of an effective patent management process for firm competitiveness, the aim of the present paper is to shed light on the intellectual structure of the literature field concerning this topic, in order to understand the current state of the art of the knowledge on the field, to outline gaps and potential areas for future research.

To pursue our goal we unveiled and analysed the patterns of common references among 103 academic papers, carefully selected according to their relevance to the topic of interest. In this respect, we relied upon bibliometric methods that, thanks to their quantifiability and objectivity, allow avoiding possible subjective biases (Nerur et al., 2008) in the identification and interpretation of the research subfields that received more attention from scholars.

In the previous paragraphs, we described, examined and systematized articles grouped in each subarea; below, starting from a further discussion of the content of each single factor, we identify gaps and highlight some aspects that represent starting points for further investigation and derive possible managerial implications.

Findings show that three main research subfields shape the structure of the "patent management" literature: "patent value", "strategic exploitation of patent value" and "technology and competitive landscape".

Articles in the first factor ("Patent value") are mainly focused on value of a single patent: through regression analyses, authors test which are the antecedents, expressing a specific patent characteristic, that are statistically associated to a certain measure of patent value. Although most of the presented antecedents (e.g., forward citations) are proven to explain a certain percentage of the variance of the actual patent value, this percentage varies from study to study (e.g., Gambardella et al., 2008; Fischer and Leidinger, 2014). This discrepancy might be due to some specific variables (e.g., industry) related to the context under investigation; thus, in this respect, it would be interesting to investigate whether these variables, acting as moderators, exercise an influence on the strength of the relationship between antecedents and patent value. Just to make an example, the industry or the country to which the patent belongs to might affect the tie between a certain antecedent and the patent value. In this sense, it would be useful to adopt a contingency perspective to develop a framework in order to clarify which are the most suitable and reliable patent value antecedents according to these moderation variables. This picture could be even more complete drawing the attention to another under investigated issue: the interaction among antecedents. In fact, previous studies do not consider whether the relationship between one antecedent and the patent value might be strengthened by other antecedents.

Finally, as previously stated, the level of analysis of papers belonging to the first factor is on "single patent", thus ignoring the presence of potential synergetic effect among patents within a portfolio (Reitzig, 2004a). Further studies might consider the interconnection among patents in the same portfolio, analysing for example patent "self citations". Self citations are those received from subsequent patents assigned to the same organization and they might represent the extent to which the firm has been able to build upon their internal knowledge and make the most of it (Hall et al., 2005). However, a patent portfolio with numerous self citations might be a signal of a "fencing" or "thicket" building behaviour where the patentees, with the aim of strengthening their patents, intensively patent alternative or related technology (Bessen, 2008; Fischer and Leidinger, 2014).

The second factor ("Strategic exploitation of patent value") collects articles concerning different kinds of strategies that a firm can adopt to exploit patents within or outside its own boundaries. However, despite the fact that authors agree that each patent within the portfolio requires a tailored exploitation strategy, from the analysis of the content of the papers, it emerges a lack of indications to guide managers in choosing and defining an appropriate patent exploitation strategy before putting it into practice.

In fact, except from Reitzig, 2004b; studies grouped in this factor mainly adopt a descriptive approach, sometimes supported by brief examples of firms whose patent exploitation strategies are simply described without a deep understanding on how firms have taken this decision.

Thus, an area of open research would be the definition of a structured set of guidelines, a tool or a framework aimed at supporting practitioners in choosing and then shaping, for each patent, an *ad hoc* exploitation strategy coherent with corporate strategy. In addition, these guidelines should also take into consideration a range of intrinsic factors, such as firm size, and external factors, such as competitive conditions, industry sector, market location and legislation, which might exercise an influence on firm patent strategy (Blind et al., 2006; James et al., 2013).

Finally, contributions belonging to the third factor ("Technology and competitive landscape") are aimed at developing methods and techniques that, analysing patent data, provide information on firm technological and competitive environment. Numerous of these methods and tools use quantitative indicators, derived from the measures of patent value antecedents discussed in factor one, to capture the nature and impact of technological inventions described in patent documents, as well described in the empirical paper of Arts et al. (2013).

However, papers dealing with this topic do not drop the method or technique they propose in the patent management process: authors did not explicitly mention whether and how the implementation of tools or methods might support managers' decisions such as the application of new patents, the definition of a patent exploitation strategy or the maintenance of the existing patents. Thus, from an academic standpoint, an effort to re-organize and classify patent analytic

tools, according to the information they can provide and thus the kind of decision they might support, would be useful. From another perspective, deeper understanding can also be helpful for practitioners: a more clear and organized overview of available patent analytical methods can increase managers' awareness about the availability and usefulness of these tools during the different phases of patent management process. In fact, as pointed out in the second factor, managers' commitment and attention are essential for a trenchant and effective patent management. In addition, despite the fact that each paper in this last set reports quantitative examples to describe the implementation and verify the feasibility of the analytical method proposed, in accordance with Lee et al. (2009), it would be advisable to test their validity also through qualitative real case studies that might highlight potential difficulties or limitations in their practical application.

Moreover, further to the above considerations related to the specific factors, some general areas which might benefit from additional investigation can be outlined.

Firstly, contrary to our expectations, the analysis of the factors shows that none of them is directly related to the topic of patent management intended as a process starting from the planning of the application for a new patent and proceeding, after its grant, to the routinely evaluation of patent worth. In other words, although authors discuss the antecedents of patent value, the possible patent exploitation strategies a firm might choose among, or the different tools useful to trace the technological and competitive landscape, there is a lack of indications on how to integrate them into the process.

This might be due to the fact that little literature (e.g., Carlsson et al., 2008) is devoted to explain and describe how this process unfolds over time, which are the specific activities to be undertaken in each stage and how these activities should be performed. In particular, since the importance of reducing time to market is increasingly stressed, it might be interesting to have a deeper understanding on how the part of the patent management process concerning the planning of a new patent might be seen as integrated or rather parallel to the new product development process (NPD). Embedding patent planning from the idea conception throughout the research and development process, might allow the firm to anticipate the search for information about the surrounding environment in order to strengthen its patent position and reduce the risk of infringing third party patents.

Therfore, once these organizational aspects have been clarified, it might be more immediate to understand how and in which phase of the patent management process, quantitative indicators of patent value and methods and tools to describe the technological or competitive environment might be adopted in order to contribute to provide the information needed to enhance the accuracy of the firm investment in filing and maintaining its patents and the firm ability to craft an incisive patent strategy.

Moreover, like any other activity or process inside a firm, patent management requires resources to be used for its implementation, too. However, few contributions (e.g., Carlsson et al., 2008; Reitzig and Puranam, 2009) offer insights regarding the actors that should to be involved in this process, the education they should possess, as well as their capabilities.

All these gaps might be filled through in-depth and longitudinal case studies. Furthermore, it might be useful to adopt an action research approach which, thanks to a direct and close collaboration between academics and managerers, may provide valuable examples about the relevance, success and failures of particular patent management practices and organizational arrangements.

Secondly, scholars should pay careful attention to the specific needs small firms experience in managing their own patents, in order to provide dedicated indications and advice to improve patent management implementation and organization in the SME context. In fact, despite small firms are widely regarded as important innovators in the economy, they face major disadvantages with respect to large corporations. As far as patent management is concerned, SMEs are found to lack of in-house expertise, but, due to monetary resource constraints, they can rely upon external advisors and patent attorneys only when extremely necessary (Eppinger and Vladova, 2013).

Table 5
Academic implications and gaps.

Academic implications and gaps	• Consider potential contextual variables that might influence the strength of the relationship between certain patent value antecedents and a measure of patent value • Consider whether an antecedent of patent value might influence the strength of the relationship between another patent value antecedents and a measure of patent value • Provide deeper understanding about how mutual synergies among patents belonging to same portfolio might exercise an influence on their value • Define a structured set of guidelines, a framework or tool to help practitioners in choosing and shaping an incisive patent exploitation strategy according also to contextual factors (e.g. industry, markets, . . .) • Reorganize and classify patent analytic tools and methods according to the information they can provide and thus the kind of decision they might support • Collaborate with practitioners in an Action Research project to better understand how the patent management unfolds and might be improved used the aforementioned indicators, methods and tools • Test in practice through qualitative case studies the feasibility, validity, potential difficulties and limitations of the analytical methods yet proposed in the literature • Provide insights regarding the actors that should to be involved in the patent management process, the education they should possess, as well as their capabilities • Draw attention to the specific needs of small firms: provide dedicated indications and advises to improve patent management implementation and organization in the SME context

Table 6
Managerial implications and recommendations.

Managerial implications and recommendations	• Be aware that patents need to be attentively managed in order to provide benefit to the firm (e.g., reduce the cost associated to file new patents or maintaining existing ones) • Collaborate with academics in an Action Research project to better understand how the patent management process unfolds and might be improved used the aforementioned indicators, methods and tools • Integrate, or conduct in parallel, the patent planning into the NPD • Use antecedents of patent value and landscape methods and tools to take informed decision about patent planning and evaluation and patent exploitation strategy • Shape an exploitation strategy for each patent paying attention also to the contextual environment

In summary, we recognise that despite the growing amount of academic contributions regarding patent management there is still room for further investigations.

For the sake of clarity, the following tables sum up what we outlined in this paragraph: Table 5 summarises the academic implications and gaps while Table 6 synthetises the managerial implications and recommendations.

5. Limitations

In comparison to other approaches addressed to assess the influence of publications or authors, such as key informants' judgements, bibliometric methods are less inclined to systematic biases (Baumgartner and Pieters, 2003). Nevertheless, these methods have an intrinsic weakness that should be mentioned too. Considering citations as reflection of knowledge transfer or intellectual contribution to subsequent works, these methods assume that a document is cited when deemed important. However, other intentions or motivations that may drive authors in citing prior documents cannot be taken into account (e.g. Glänzel and Schoepflin, 1999). Furthermore, in bibliographic coupling, papers with relatively longer bibliography are overweighted, since they are more likely to have interconnections with other publications (Voegel and Güttel, 2012).

In respect to factor analysis, another shortcoming is due to the fact that papers with loads, between 0.5 and 0.7 on more than one factor could not be assigned univocally to one of them. Thus, these articles were not included in the discussion and interpretation of a single factor, despite extending their specific research topic on more literature subfields, they represent interrelations between different topics.

Finally, our sampling approach is particularly selective. First of all, the keywords used to select our initial sample were chosen in order to precisely reflect the adopted definition of patent management. Secondly, we relied only upon journal articles published in one single database, therefore, the sample might be enlarged in the future to include more contributions.

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Appendix A.

Table 2
Factor analysis results[a] for the papers in the intellectual core of "patent management" literature.

Author(s)	Factor 1	Factor 2	Factor 3
Belderbos et al. (2014)	**0.917**		
Bessen (2008)	**0.951**		
Blind et al. (2009)	**0.888**		
Chen and Chang (2010)	**0.844**		
Chi and Levitas (2007)	**0.731**	−0.500	
Fischer and Leidinger (2014)	**0.967**		
Gambardella et al. (2008)	**0.955**		
Gambardella (2013)	**0.917**		
Grönqvist (2009)	**0.868**		
Guellec and de la Potterie (2000)	**0.932**		
Hall et al. (2005)	**0.940**		
Harhoff et al. (2003)	**0.963**		

Table 2 (*Continued*)

Author(s)	Factor 1	Factor 2	Factor 3
Harhoff et al. (1999)	**0.967**		
Hegde and Sampat (2009)	**0.941**		
Hsieh (2013)	**0.673**		
Kossovsky et al. (2004)	**−0.709**		
Lanjouw et al. (1998)	**0.942**		
Levitas and Chi (2010)	**0.741**		
Reitzig (2003)	**0.888**		
Reitzig (2004b)	**0.962**		
Reitzig and Puranam (2009)	**0.762**		
Suzuki (2011)	**0.963**		
Tekic and Kukolj (2013)	**0.819**	0.479	
Trajtenberg (1990)	**0.402**		
Wu and Tseng (2006)	**0.854**		
Al-Aali and Teece (2013)		**0.764**	0.496
Baglieri and Cesaroni (2013)		**0.747**	0.408
Bekkers et al. (2002)		**0.416**	
Bromfield and Barnard (2010)		**0.873**	
Candelin-Palmqvist et al. (2012)		**0.401**	
Carlsson et al. (2008)		**0.809**	
Chesbrough (2003)		**0.790**	
Eppinger and Vladova (2013)		**0.832**	
Fisher and Oberholzer-Gee (2013)		**0.834**	0.438
Gallié and Legros (2012)		**0.860**	
Granstrand (2000)		**0.499**	
Hanel (2006)	0.500	**0.781**	
Holgersson (2013)		**0.765**	0.488
Li and Ni (2012)		**0.835**	
Lin et al. (2006)		**−0.594**	
Motohashi (2008)		**0.792**	
Peters et al. (2013)		**0.685**	
Reitzig (2004a)		**0.913**	
Reitzig (2007)		**0.864**	
Somaya (2012)		**0.812**	0.420
Tamura (2012)		**0.713**	
Teng (2007)		**0.814**	
Thumm (2004)	0.430	**0.777**	
Tsuji (2011)		**−0.629**	
Vismara (2014)		**0.664**	
Ziegler et al. (2013)		**0.788**	0.456
Abraham and Moitra (2001)			**−0.877**
Ashton and Sen (1989)			**−0.773**
Chang (2012)			**0.403**
Di Minin and Faems (2013)	−0.500		**0.723**
Ernst (1998)		−0.486	**−0.711**
Keep et al. (1994)			**−0.771**
Liu and Shyu (1997)			**−0.806**
Lo Storto (2006)			**0.667**
Mogee (1991)		−0.500	**−0.709**
Tsuji (2002)			**0.605**
Alexy et al. (2009)	−0.629	0.265	0.440
Bader (2008)	−0.607	0.296	0.502
Breitzman et al. (2002)	0.224	−0.676	−0.526
Breitzman and Thomas (2002)	0.224	−0.676	−0.526
Brockhoff et al. (1999)	0.402	−0.600	−0.528
Cao and Zhao (2013)	−0.082	0.524	0.632
Chen and Chen (2007)	−0.527	−0.020	−0.563
Collinson et al. (2005)	0.466	0.298	0.468
Conley (2013)	−0.368	0.480	0.573
den Uijl et al. (2013)	−0.300	0.364	0.185
Geum et al. (2013)	0.668	−0.539	−0.216
Granstrand and Holgersson (2013)	−0.290	0.655	0.596
Greenberg (2013)	0.601	0.617	0.319
Lee et al. (2012)	0.646	−0.474	−0.354
Lee et al. (2009)	−0.057	−0.587	−0.600
Maas (2000)	−0.401	0.480	0.091
Mogee and Kolar (1994)	0.173	−0.617	−0.584
Orozco (2010)	−0.422	0.338	0.496
Petrick et al. (2014)	−0.698	0.124	0.511
Pisano and Teece (2007)	−0.610	0.171	0.693
Pitkethly (2001)	−0.147	0.457	0.580

Table 2 (*Continued*)

Author(s)	Factor 1	Factor 2	Factor 3
Roy and Sivakumar (2011)	−0.572	0.184	0.630
Saracho (2002)	−0.425	0.606	−0.011
Seldon (2011)	−0.698	0.124	0.511
Smith (2007)	−0.698	0.124	0.511

Bold values represent the paper significant load on the factor it belongs to.

[a] According to Vogel and Güttel (2013), we decided to include in our bibliographic coupling analysis only those core articles that cite, at least, one reference paper that has been cited by, at least, other two core articles.

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