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Review

Roots and development of intellectual property management research: A bibliometric review

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ABSTRACT

In recent years, intellectual property (IP) has become a crucial aspect in modern management practices, especially for innovative technology-based organizations. Correspondingly, growing numbers of studies are conducted each year to address various aspects of IP management (IPM). Nevertheless, the research field is still relatively fragmented and researchers lack a systematic understanding of the existing body of knowledge. The purpose of this paper is to investigate the underlying knowledge structure and the evolution of IPM research. To accomplish this goal, we analyzed 773 source articles published between 1980 and 2012 using bibliometric techniques including citation and co-citation analysis. We broadly searched for research articles that focused on IP management in the two largest academic databases (Web of Science and Scopus) and manually refined the search results. The results indicate that intellectual property management is a fast-growing research field with theoretical roots in law, economics, and management. Based on the citation data, we identified the most cited studies that form the intellectual core of IPM research. A co-citation diagram was plotted and five main research themes were uncovered. The center of the diagram is formed by studies on the role of IP in improving firms' appropriability. Surrounding the center are studies on the openness of IP strategy and the economic impact of the patent system; the former has become a heated topic over the recent decade, while the latter has lost popularity. Another two groups of studies emerged at the rear of the diagram, namely IP valuation and optimal IP licensing strategy. The article concludes by providing suggestions and implications for future research.

1. Introduction

As shown by many indicators and recognized by many scholars, the last few decades have witnessed an ongoing transition to a knowledge-based economy [1,2]. According to economists, knowledge is a common type of public resource and is non-excludable in nature [3]. In order to appropriate value from R&D and innovation efforts, intellectual property rights (IPR) are needed to protect valuable knowledge. The importance of managing intellectual property (IP) has been realized by more and more managers, especially those in technology-intensive firms. Among recent technology headlines was Google's acquisition of Motorola Mobility for $12.5 billion; the transaction was primarily initiated for the 1700 wireless patents Motorola held, which were essential for Google's strategic move into the consumer electronics market. At the same time, we have seen a surge in the number of academic studies and publications in the field of IP management (IPM). The research field of IPM emerged from diverse roots in economics, law, and management [4] and has grown rapidly over recent years and accumulated its own body of knowledge. Nevertheless, the field is still fragmented and lacks clarity in its research trajectories [5]. Therefore, a comprehensive study on the current status, future trends, and underlying intellectual structure of the field of IPM is needed.

From a legal perspective, the term “intellectual property” (IP) refers to a creation of the mind for which exclusive rights are recognized [6]. Common forms of intellectual property rights include patents, trademarks, copyrights, and trade secrets. Intellectual property has long been treated as legal assets. However, it

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was not until recently that both academic researchers and practitioners started to view IP as business assets from which value could be derived [7]. This transition is also reflected in how firms deal with IP issues in their daily operations. In the past, activities related to IP were mostly carried out by the legal department of the organization or outsourced to law firms. Currently, we see more involvement of personnel from business and strategy, as well as R&D, in IP related activities, such as patent filing and licensing decisions, or enforcement of IP rights [8]. To some extent, the combination of expertise in various aspects, including law, management, economics, technology, and public policy, has contributed to the fragmented nature of IP management research.

This study addresses the gaps in our understanding of the field by using bibliometric techniques to uncover the knowledge structure of IPM research. Our study differs from previous reviews in two ways. First, instead of focusing on the consensus list of "key articles" or papers from a few specific journals, we searched broadly for all relevant papers in IP management. By conducting a citation and co-citation analysis of this large sample, we are able to acquire a comprehensive understanding of the current status and the evolution of this research domain. Second, unlike prior qualitative reviews [4,5,9,10], we adopted quantitative methods and provided objective clues on the knowledge structure of the field. Based on the results of the bibliometric analysis, we provided a broad overview of the research field and identified the intellectual core and the underlying knowledge structure. Moreover, we showed how the field of IP management has evolved over time and offered suggestions and implications for future research.

In Section 2, we present a summary of previous review papers on IP management. Section 3 gives a brief introduction of the bibliometric techniques adopted in this study. Section 4 provides further details on the data and methodology. The results and discussions are presented in Section 5. Section 6 concludes with the major findings of this paper and suggestions for future research.

2. Literature review

The process of intellectual property management is the means through which companies or individuals maintain their patents, trademarks, copyrights, and trade secrets. Activities involved in this process can be as simple as obtaining IP rights and keeping them renewed, or as complicated as developing an integrated IP strategy and aligning it with business strategies [7]. The most important objective of IP management is to ensure that all intellectual property is being used to its fullest extent and serves to maximize profitability [11].

Several studies have analyzed and reviewed the IP management research. Previous review papers summarized various research topics related to IP management and depicted the current status of IP management as a field of study within management. In one of the earliest review papers on IPM, Hanel [9] surveyed the IPM literature and classified IPM studies into different groups based on their primary focus. After a careful review of the existing IPM literature, the author came to the conclusion that intellectual property is becoming an increasingly important business asset for firms. Swain and Panda completed a bibliometric study on 332 articles published in the Journal of Intellectual Property Rights from 2002 to 2010. The results indicated that the degree of collaboration in the journal was relatively low, with nearly three quarters of the articles having a single author. In addition, it was found that the articles were rarely cited and the majority of the citations came from the source journal. Nevertheless, the Journal of Intellectual Property Rights is recognized by scholars around the world and is becoming a promising journal in the field of IP management [10]. In 2012, Hanni, Birgitta, and Ulla-Maija wrote a review paper on IPR studies in innovation management research. Their paper covered 111 articles from seven leading innovation management journals. Similar to Swain and Panda's paper, both descriptive statistics and qualitative observations were reported. Moreover, this review article provided suggestions for future IPR research. In particular, the authors pointed out that research methodologies used in future IPR studies should be more versatile and more studies should be conducted in Asian contexts [5]. Another frequently cited qualitative review was done by Somaya in 2012. The author provided an overview of patent strategy and management research. According to his framework, firms generally adopt three different kinds of patent strategies, namely proprietary, defensive, or leveraging strategies [4]. Most of the source articles analyzed in this paper were from the management literature and investigated firm-level strategies in managing IP.

In sum, previous review papers on IP management either adopted a qualitative approach or focused on a select part of the literature. As a result, there is still little agreement among scholars on what exactly constitutes IPM research. In this paper, we aimed to address the gap in our understanding of IPM research and how the underlying knowledge structure has evolved over time. We achieved this goal by using standard bibliometric techniques, including citation and co-citation analysis. In order to avoid any bias in the selection of articles, we broadly searched for all IPM research papers using two databases. A comprehensive list of IPM articles was constructed upon which further bibliometric analysis was performed.

3. Bibliometric techniques

The term "bibliometrics" was coined by Alan Pritchard in 1969 and refers to the application of mathematics and statistical methods to books and other media of communication [12]. Since its introduction, bibliometrics has been adopted by scholars in various fields to quantitatively analyze scientific and technological publications. Common bibliometric techniques include citation analysis, co-citation analysis, and bibliographic coupling. In this paper, we adopted the former two methods to reveal the underlying structure of IPM research.

Citation analysis is based on the rationale that authors cite papers they consider to be important to the development of their own research. Therefore, heavily cited articles are likely to have a greater influence on the subject than less cited ones. Based on the citation rates of the references, we were able to identify the core literature upon which the research field was developed. However, citation analysis alone cannot provide a clear view of the structure of a field [13]. Therefore, in this paper, co-citation analysis was carried out following the citation analysis.

Co-citation is defined as the frequency with which two items of earlier literature are cited together by the later literature [14]. Since its introduction in 1973, co-citation analysis has been applied to various fields of research including information science [15], strategic management [16], operations management [17], human resource management [18], etc. According to the definition, if two papers are strongly co-cited, a large number of authors must cite the two earlier works together [14]. Therefore, by measuring co-citation strength, we measure the intellectual connections within the field [19]. Moreover, in order to be frequently co-cited, the two papers must have been frequently cited individually. Therefore, highly co-cited papers are likely to represent the key concepts, methods, or experiments in a specific field [20]. Consequently, by conducting a co-citation analysis, we can uncover the intellectual structure of a research field [21].

There have been heated debates over the two different bibliometric methods over the years [22]. Bibliographic coupling, which

measures the number of shared references of two papers, has been widely used to detect subfields in a research domain. In contrast, co-citation analysis focuses on antecedent works cited by the source articles and is dynamic in nature. As illustrated in Section 2, there is an abundance of review papers on IP management looking at the current status of the research field. Moreover, as we will see from the descriptive statistics in Section 5, IPM is a fast-growing, yet not fully-established, field. This means it is still too early to identify subgroups or subtopics within IPM. The main purpose of this study was to uncover the intellectual roots of IPM as a research field and how its intellectual structure has evolved over time. Therefore, we adopted co-citation analysis to achieve this goal.

4. Data and methods

4.1. Sample preparation and refinement

Since the aim of our study was to uncover the intellectual structure of the research domain, we focused on relevant publications in academic journals. Compared to books, unpublished doctoral theses, and other documents, journal articles are considered as more "certified" knowledge [16] because they have undergone critical review by fellow researchers. Moreover, journal articles cite previous works in a more standardized way, through which we can observe the knowledge flows within the field.

We searched for all articles published from 1980 to 2012 with "intellectual property management/strategy/licensing/portfolio/valuation" or "patent, trademark, copyright, trade secret management/strategy", as well as their abbreviated forms (IP, IPR, IPM, etc.), in the article title, abstract, or keywords. To avoid the limitations of a single database, we searched both Web of Science and Scopus (duplicated articles were manually excluded) in the subjects of law, economy, and management. In order to avoid any deficiency of the search criteria or limitations of the database coverage, we performed a cross-check of the three journals that published the most articles related to IP management (as identified by the search results – Research Policy, International Journal of Technology Management, and Journal of Intellectual Property Rights). We manually examined each issue of these three journals between 1980 and 2012 and extracted any articles focusing on IP management that were not covered by our search results. Using this procedure, we identified 19 additional source articles.

The above search and cross-check processes returned more than 2000 articles. Since the list of articles was generated by the search engine using a combination of keywords, further refinement was necessary to exclude papers that did not fit our scope. To avoid subjectivity in the refinement process, we engaged independent researchers to determine which papers to exclude and solved any disagreements through discussion and careful review of the entire article. We excluded the following types of papers:

- Studies that used patents merely as indicators of innovative output or research capabilities and focused on research topics other than IP management per se;
- Technological papers introducing or describing a new patent analysis tool (software, algorithm, etc.);
- Patent map/landscape studies of a specific technology area aimed at forecasting future technology trends;
- Inappropriate document types (books, book reviews, keynote addresses, editorial documents, unpublished doctoral theses, incomplete conference proceedings, etc.).

After the refinement, we retained 773 papers published in academic journals from 1980 to 2012.

4.2. Coding and purification

Due to random errors in both databases, around 8% of all articles in the sample had one or more fields with missing content. We manually retrieved these problematic records and completed the missing fields. After this process, we ensured that each article in our sample was recorded in a standard format, including the title, author name, abstract, keywords, publication year, source journal, and a list of cited references.

To conduct a co-citation analysis on the sample, we relied on the citation list of each article to generate co-citation networks. Therefore, any mistakes in the cited references could lead to inaccuracy in the next stage and needed to be fixed before further analysis. Common mistakes in the cited articles included misspellings or variants in author and journal names and abbreviations, as well as wrong or missing volume and page numbers. For cited references in the form of books, additional attention was paid to correct for multiple editions and inconsistent abbreviations of book titles. After this procedure, the purified sample was ready for further bibliometric analysis. The sample set used in our study consisted of 773 articles with 33,743 cited references.

4.3. Citation and co-citation analysis

Using the cleansed dataset, we carried out a citation and co-citation analysis. Citation analysis generates descriptive statistics about the source articles and gives us a brief overview of the

Table 1
Intellectual core of IP management research.

Cited references	Times cited	Frequency (per 10,000 citations)			
		Overall	1980–1999	2000–2012	Change
Levin RC, 1987	136	40.30	39.69	40.38	0.68
Cohen WM, 2000	125	37.04	NA	41.71	41.73
Arrow K, 1962	120	35.56	0	34.70	34.70
Hall BH, 2001	113	33.48	NA	37.71	37.71
Teece DJ, 1986	96	28.45	0	27.03	27.03
Shapiro C, 2000	84	24.89	NA	28.03	28.03
Merges RP, 1990	81	24.00	31.75	23.02	−8.72
Heller MA, 1998	75	22.22	0	25.03	25.03
Kamien MI, 1986	74	21.93	13.23	23.02	9.796
Arora A, 2001	65	19.26	NA	21.69	21.69
Katz ML, 1985	63	18.67	18.52	18.68	0.16
Scotchmer S, 1991	62	18.37	26.46	17.35	−9.10
Mansfield E, 1986	62	18.37	26.46	17.35	−9.10
Grindley PC, 1997	61	18.07	2.64	20.02	17.37
Kamien MI, 1992 (H)	58	17.18	7.93	18.35	10.41
Katz ML, 1986	57	16.89	18.52	16.68	−1.83
Kitch EW, 1977	55	16.29	29.10	14.68	−14.42
Gallini NT, 1990	53	15.70	7.93	16.68	8.74
Anand BN, 2000	52	15.41	NA	17.35	17.35
Lanjouw JO, 2001	50	14.81	NA	16.68	16.68
Taylor CT, 1973	50	14.81	31.75	12.68	−19.07
Green JR, 1995	49	14.52	10.58	15.01	4.43
Trajtenberg M, 1990	48	14.22	15.87	14.01	−1.86
Griliches Z, 1990	47	13.92	23.81	12.68	−11.13
Mansfield E, 1981	47	13.92	29.10	12.01	−17.09
Cohen WM, 2002	45	13.33	NA	15.01	15.01
Lerner J, 1995	45	13.33	15.87	13.01	−2.86
Jaffe AB, 2004	44	13.03	NA	14.68	14.68
Nordhaus WD, 1969	44	13.03	34.40	10.34	−24.05
Hall BH, 2005	43	12.74	NA	14.35	14.35
Lerner J, 1994	43	12.74	5.29	13.68	8.39
Kamien MI, 1992 (J)	43	12.74	5.29	13.68	8.39
Lemley MA, 2007	43	12.74	NA	14.35	14.35
Lemley MA, 2001	42	12.44	NA	14.01	14.01
Arundel A, 2001	41	12.15	NA	13.68	13.68
Wang XH, 1998	41	12.15	0	13.68	13.68
Jensen R, 2001	40	11.85	NA	13.34	13.34
Gilbert R, 1990	39	11.55	18.52	10.67	−7.84

research field. The major tool we used for the bibliometric analysis was Bibexcel, a software capable of extracting fields from article records and generating files compatible with Pajek, Excel, and SPSS for advanced analysis [23].

It is generally accepted that citation counts can be used as an indicator (although an imperfect one) of the quality of a scientific contribution [24]. Based on this rationale, we identified the references with the highest number of citation counts to represent the intellectual core of the field. It is worthwhile to point out that the criterion applied here differs from previous bibliometric studies in other fields [25]. By citation count, we refer to the number of times a reference was cited by the source articles in our sample set, rather than the total number of forward citations it has received. We believe this method leads to more accurate results since the field of IP management borrows ideas from multiple disciplines. Citations by papers from research fields other than IP management would not reflect the actual importance of their contribution to IP management research. Therefore, we only included citations by articles in our sample to generate the intellectual core. Further co-citation analysis was performed on the intellectual core detected at this stage. In order to generate a clear co-citation map, we imposed a threshold of 5% in deciding the intellectual core. In other words, references cited by more than 5% (i.e., more than 39 times) of the source articles were retained for co-citation analysis. This procedure yielded 38 cited references as listed in Table 1.

Of all the references identified as the intellectual core, none are general methodological references. These references are cited for their insights and contributions to the research field, rather than serving as common research methodologies. This further reflects the fact that there is no dominant methodology in the field of IPM research [26]. At the current stage, both qualitative and quantitative approaches are adopted by IPM researchers. Some studies used cases and interviews to explain organizations' IP practices, while others conducted surveys or analyzed patent data to provide empirical findings regarding IP management issues. Another group of studies combined the two approaches by explaining the phenomenon or problem through cases or semi-structured interviews, and then provided empirical analysis to validate the findings.

To study the linkages and structures of the intellectual core of IPM, we calculated the co-citation frequencies using Bibexcel. We split the source articles into two different periods so that we were able to observe the shifts and evolution in the underlying knowledge structure: the early period contains 97 articles published from 1980 to 1999, while the later period covers the remaining 676 articles published from 2000 to 2012. The year 2000 was chosen as the dividing point for two reasons. First, based on the results shown in the first column of Table 1, several articles that were highly impactful in the field were published around 2000 [27–31]. This suggests that the intellectual core started to build gradually during this period. Secondly, the TRIPS (Trade Related Aspects of Intellectual Property Rights) agreement, which took effect in 1996, would have an influence on both industrial practices and academic research after a certain period. Therefore, we expected a surge in the literature forming the underlying knowledge structure of the field. Consistent with the criteria we applied to the whole sample, references cited by more than 5% of the source articles in each period were retained for co-citation analysis. This resulted in 41 references cited more than 5 times by articles in the early period and 41 references cited more than 34 times by articles in the late period.

We first calculated the co-citation frequencies of the most cited references using Bibexcel. The result for this step was a symmetric proximity matrix. The number in each cell is the number of times each paper was co-cited. According to Leydesdorr and Vaughan [32], a symmetric proximity matrix can be directly input into mapping software to generate a network diagram. Further normalization is not necessary and may even lead to distorted results. Therefore, we applied the co-citation matrix directly in Bibexcel to generate the net-file for mapping with Pajek. We chose the Kamada–Kawai spring embedded algorithm [33] in Pajek [34], which seeks to minimize the total energy of the system.

5. Results and discussion

5.1. Descriptive statistics on core papers and cited references

Figure 1 below shows the number of articles published in the field of IP management by year in different subjects. The classification is based on the discipline categorization in Web of Science and Scopus. As can be seen from the chart, the very early IPM papers found their way into the law and economics literature, while more recent studies were conducted in the management domain. This finding is not difficult to understand since IP protection is provided by the legal system and the initial aim of IP was to encourage innovation and promote the economy. In the early days, most companies saw IP purely as a legal asset and activities related to IP were mostly carried out within legal departments. In the recent decade, more and more companies started to view IP as an important business asset as well [7]. At the same time, research in IPM began to identify various roles that companies assigned to IP beyond its traditional function of providing exclusivity (e.g., conflict avoidance, revenue generation, cost reduction, strategic position, etc.).

There was a surge in the publication trend around 2000. As mentioned earlier, the TRIPS agreement, which took effect in 1996, raised awareness of IPM research. Moreover, the publication of many impactful IPM studies [28–30,35] around 2000 also facilitated the development of the research field (as shown in Table 1). In recent years, more than 80 papers have been published annually with a focus on intellectual property management.

Figure 2 lists the source journals that have published papers related to IP management. The publication pattern is relatively scattered. The 15 journals that published most articles in the sample accounted for 41% of the total publications in this field. Among them, Research Policy, International Journal of Technology Management, and Journal of Intellectual Property Rights are the three journals that published the most IPM related papers.

As mentioned above, we can identify the most frequently cited references in the field of IP management from Table 1. The second column indicates the number of times each reference was cited by the 773 source articles in our sample. As one of the most important theoretical foundations of IPM research, studies on firms' appropriability through IP are the most cited [28,36,37]. These include Teece's seminal paper on appropriability in 1986, followed by Levin's paper in 1987 and Cohen's paper in 2000.

In addition, many relatively recently published articles appear on the list, which indicates their significant impact and recognition among IPM scholars. Among them is Lemley's 2007 paper in *Texas Law Review* which discussed the issue of patent holdup and royalty stacking in the current US patent system, specifically in cases where the patent involved protects one aspect of a complex product [38]. Also noteworthy are Hall's 2005 RAND paper and Jaffe's 2004 book. Hall's 2005 paper focused on the correlation between patent citations and the value of the patent [39]. This paper was heavily cited by studies in patent valuation. The book by Jaffe in 2004, on the other hand, discussed the impact of the patent system on innovation and the economy [40]. This book is often cited by law and economics journals and studies on patent policies at the national level.

The last four columns of Table 1 show the citation frequency in the different periods and the changes between them. Citation frequency is calculated as the number of times cited per 10,000 citations [17]. The change in citation frequency is also plotted in Fig. 3

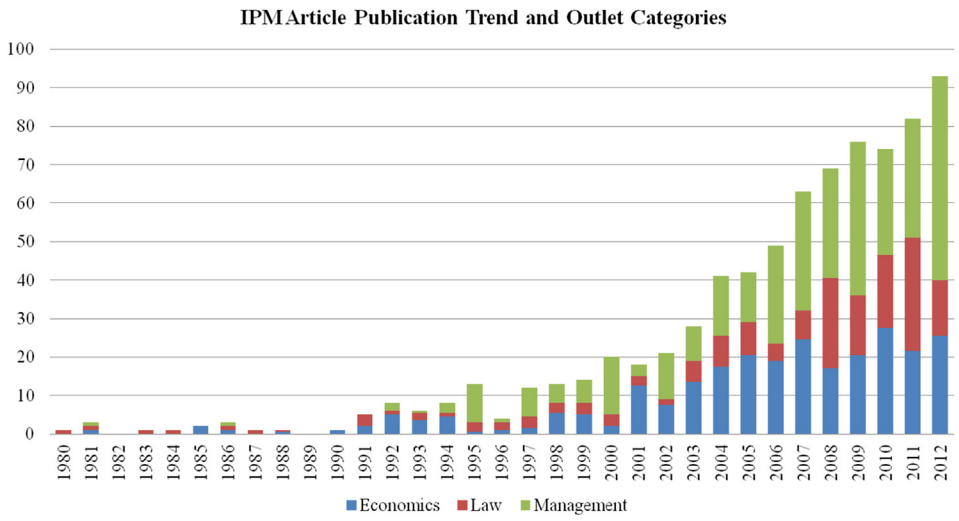

Fig. 1. Publication trend and outlet categories.

for a clearer view. This analysis aims to investigate how the intellectual structure changed during the two periods. A series of important studies was published around the year 2000 which added to the knowledge base of IPM research. A few representatives of these studies include Cohen's paper in 2000 on appropriation mechanisms adopted by US manufacturing firms [28], Hall's paper in 2001 on patenting propensity among semiconductor firms [30], and Shapiro's paper in 2000 on the issue of patent thickets [29]. The most important reason for their high citation rates is that the topics they covered appealed to broader audiences. The insights of these articles attracted both scholars and practitioners from management, law, and economics.

As shown in Fig. 3, some references became more frequently cited while others lost popularity over the years. One interesting example is Arrow's book chapter titled "Economic Welfare and the Allocation of Resources for Invention" [41]. The book was initially published in 1962, but it was not until 2000 that researchers in IP management started to adopt his theories in welfare economics and began to cite this reference. Another case is Teece's *Research Policy* paper in 1986, which is regarded as one of the seminal papers on appropriability [36]. The paper explained why innovative firms often failed to profit from their innovation outcomes. Firm-level studies on firms' appropriability were mostly seen in the later period, and researchers in IPM started to bring the term "appropriability" into IPM research and cite this paper only after 2000.

On the other hand, some references were highly cited in the early period (1980–1999), but lost popularity in recent years. Nordhaus's 1969 book on technological change and social welfare provides an appropriate example. This book was mostly cited for its discussion of optimal patent life in Chapter 5. It is one of the most cited references by the source articles in the early period, but is only moderately cited by more recent studies. Taylor's 1973 book on the economic impact of the patent system [43] is another such instance and it had a citation rate of 31.75 (per 10,000 citations) among articles in the early period. However, the rate dropped to 12.68 in the late period, resulting in an overall citation frequency of 14.81. This change, together with the trend depicted in Fig. 1, suggests that earlier works in the field of IPM tend to deal with the economic impacts of IP on social welfare, while the more recent studies have focused on firm-level management of intellectual property.

5.2. Co-citation analysis

In order to explore the underlying knowledge structure of the research field, we conducted a co-citation analysis on the source articles. As mentioned earlier, co-citation analysis was performed

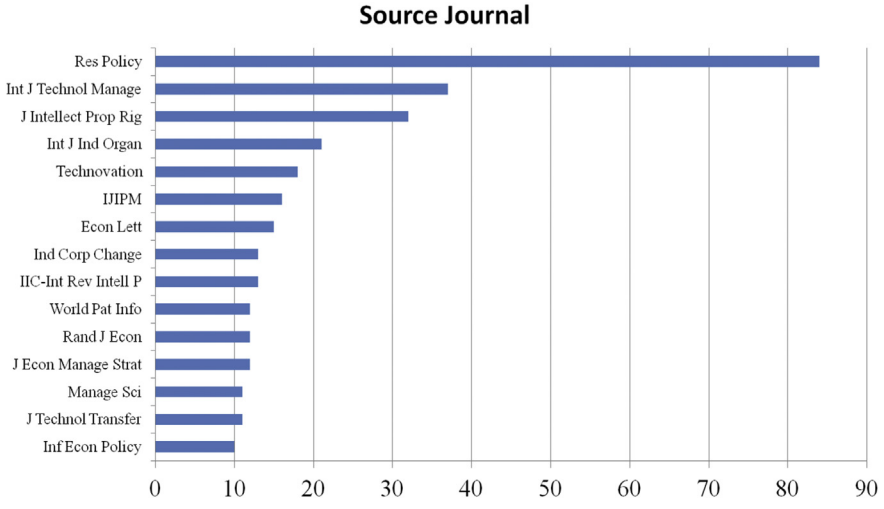

Fig. 2. Distributions of source journals.

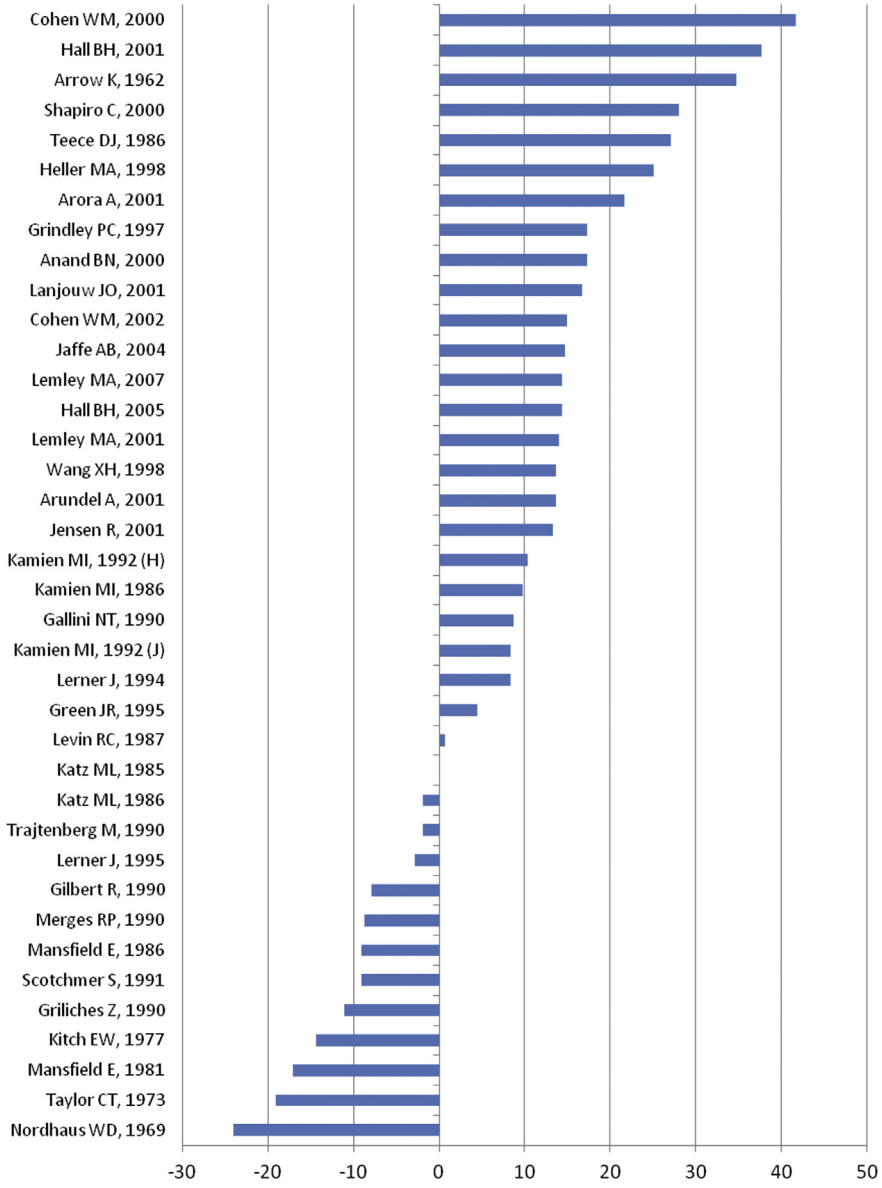

Fig. 3. Changes in citation rates over the two periods (per 10,000 citations).

on the most frequently cited references. Articles that were cited by more than 5% of the source articles were included in our analysis. This resulted in 38 references for the entire period, 41 references for the early period, and 41 references for the late period.

In the citation diagram, the size of each node reflects its citation frequency. The position of each node is determined by its co-citation frequency with other references: highly co-cited papers are located close together, while less co-cited papers are further apart. In addition, the co-citation strengths are reflected by the thickness and gray-scale of the lines between them. To produce a clearer network diagram, we set a cut-off value for the lines to be displayed. In the diagram for the entire period, lines with values lower than 13 were omitted. For the early and late periods, the cut-off values were set to 3 and 13, respectively.

As can be observed from Fig. 4, the center of the co-citation diagram consists of the most frequently cited references by IPM studies. These include papers on how firms can appropriate from their innovation through IP [36,37,44] and the relative effectiveness of IP in providing protection against competitors and imitators across different industries [30,45–49]. Among them, Teece's paper in 1986 [36] was one of the first to mention the importance of appropriation regime and Mansfield's papers in 1981 and 1986 [48,49] were the earliest empirical studies exploring how the level of appropriability provided by IP protection varied in different industrial settings. This topic remains one of the central themes of IPM research. Many later studies on this issue followed the frameworks and methodologies developed by this literature.

Above the center are three studies that investigated how firms adopt relatively “open” IP strategies through cross-licensing [50], participation in patent pools and standard setting organizations [29], and how the market for technology is formed and how firms should react to it [35]. The openness of IP strategies is an especially heated topic in current IPM research and its study has attracted scholars from open innovation as well [51,52]. This emerging group of studies explored the new challenges and opportunities to develop the most efficient IP strategies for firms playing in a more open business environment.

On the lower right of the diagram is a group of papers that discussed the function and nature of the patent system from an economics perspective. These studies investigated the economic

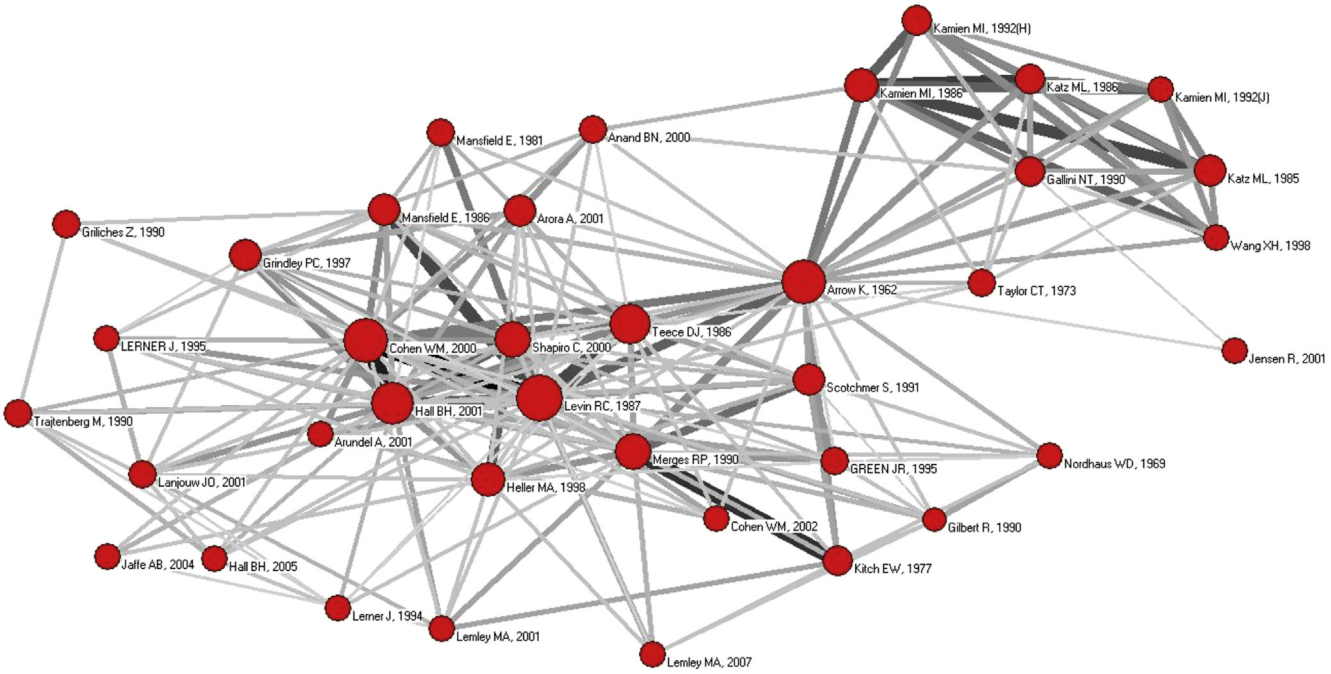

Fig. 4. Co-citation network diagram – whole sample (1980–2012).

impact of the patent system [41–43,53–55], whether the existence of this system is deterring or promoting innovation [40,56], and how the optimal patent length and scope should be determined to ensure the most efficient patent system [57,58]. This stream of literature has been less popular in recent years since the patent systems in most developed countries are already well-established. The research focus has shifted from the system per se to how individual firms in the system can perform better through effective IP management.

The lower left corner of the diagram consists of studies on IP valuation. The topics covered include how citation data can be applied to determine the value of a patent [39,59,60], how the scope of a patent is related to its economic value [47], and what characteristics of a patent could lead to a higher possibility of being involved in litigation [31]. The existing studies on IP valuation are largely built upon these papers. Although more indicators (family size, originality, imitation barriers, etc.) and methods (income, cost, market, direct, pay-off) have been developed, citation and scope still remain important indicators of patent value.

The upper right corner of the diagram contains a group of articles that are relatively distant from the core. These articles focused on optimal licensing strategies for firms (fees versus royalty, degree of exclusivity, etc.) under different conditions and specific issues involved in contract design [27,61–67]. The topic of IP licensing strategy remains an important research area in IPM. More and more firms have started to realize that a well-designed licensing strategy can generate additional revenue which fuels future R&D.

In Hanel's *Technovation* paper, the existing IPM studies were classified and discussed. Topics like IP valuation and the role of IP in improving firms' appropriability were also mentioned. However, the topic of the economic impact and function of IP systems was not covered in Hanel's paper. Even though research on this topic is an important part of the IPM knowledge base, few recent studies have examined this issue. According to Hanel, in addition to the topics identified in our co-citation diagram, research topics that have emerged in recent years include human resources, training of IP personnel, the effect of IP on firm value, etc. [9].

Figure 5 shows the co-citation network for the early period (1980–1999). The co-citation pattern for this period is relatively scattered as the field was still in its initial development stage. The literature used for the co-citation analysis for this stage included most of the core references listed in Table 1. As can be seen in the upper right corner, the group of papers by Katz, Kamien, Gallini, and Gilbert on optimal IP licensing strategies had already emerged at this time.

In the upper left corner there exists a group of frequently co-cited papers that was not observed in the co-citation diagram for the whole sample. Most of these papers were published in law journals and focused on either the rationale behind the patents or the copyright system [68–75]. As the patent systems for most nations have become more mature and established over the years, fewer discussions on this topic were seen in the recent decade.

As can be seen from Fig. 6, the co-citation pattern for the late period is very similar to that for the whole sample. The main reason is that this period contains 87% of the source articles. This echoes findings by previous review papers that showed that IP management is a young and fast-growing field and most of the IPM publications emerged in the last twenty years [5]. Another reason for the similarity is that earlier publications tend to have fewer references than recent ones. And, since the co-citation diagram is constructed upon citation data, the citation pattern for the whole sample is more driven by articles in the late period.

In addition, there are two papers by Harhoff that appear in Fig. 6 but not in Fig. 4. These two papers, together with the group of papers on IP valuation mentioned earlier, explored the relationship between citation, family size, and patent value [76,77]. Another article that was not included in the citation diagram for the whole sample is Mazzoleni's 1998 paper which discussed the benefits and costs of a strong patent system [78]. Since these papers were published around 2000, they did not receive many citations in the early period (1980–1999). Therefore, the overall citation rates of these papers were not high enough to be included in the co-citation map for the entire period.

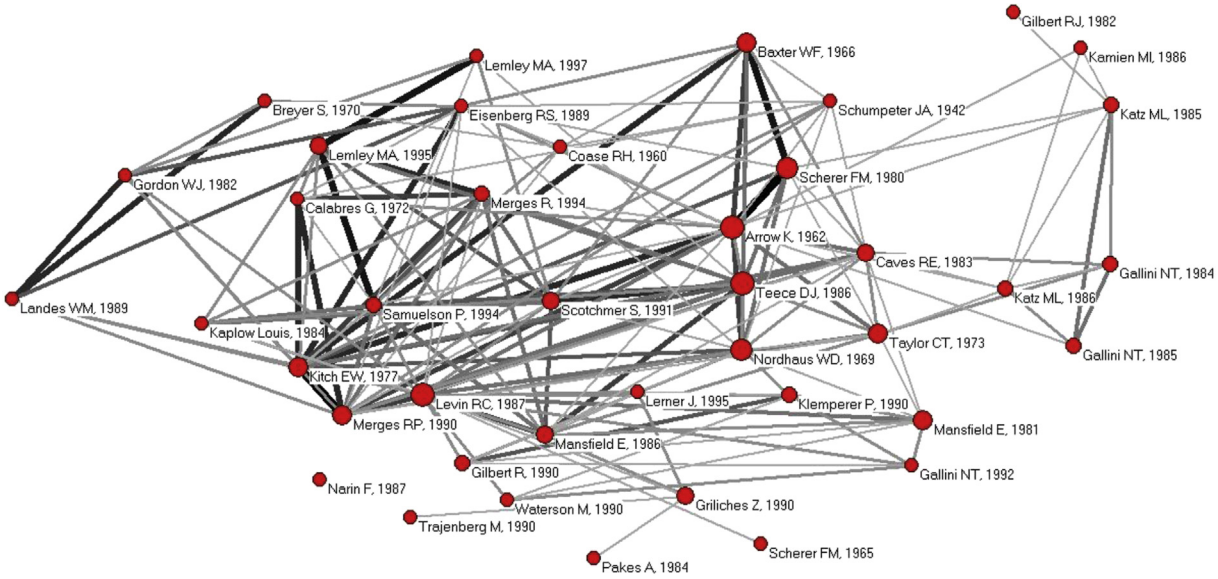

Fig. 5. Co-citation network diagram – early period (1982–1999).

6. Conclusions

The aim of this paper was to explore the knowledge structure of intellectual property management research. Based on the above analysis of the existing literature, IP management is a relatively young and fast-growing research field. At this stage, we feel it is imperative for IPM researchers to have a better understanding of the intellectual roots of this research field. Unlike previous reviews which either used qualitative approaches or focused on publications from a single journal, we conducted our study on a comprehensive sample of articles and applied bibliometric techniques to provide sizable clues on how the research field has developed over the years. Our paper makes three important contributions to the literature.

First and foremost, by studying all academic articles in IP management, we provided objective insights on the current status of this research field. Based on the analysis of 773 source articles, IP management research is multidisciplinary in nature and integrates knowledge from law, economics, and management. Researchers in the field also have various backgrounds ranging from management to economics, law, and science and engineering.

Although this paper covers a time span of more than 30 years (1980–2012), most IP management publications emerged in the present decade. According to some IP management consultants, the volume of patent transactions has grown rapidly in the past few years [79]. Industrial development often drives academic research, as shown in the case of the petroleum industry where increases in oil prices are associated with growth in academic publications on the same topic [80]. Similarly, with increasing volumes of IP transactions, we expect to see growing numbers of academic publications in the field of IP management.

Secondly, judging from the publication patterns in the field, it appears there is a lack of an impactful academic journal focusing specifically on the topic of IP management. Most of the articles in

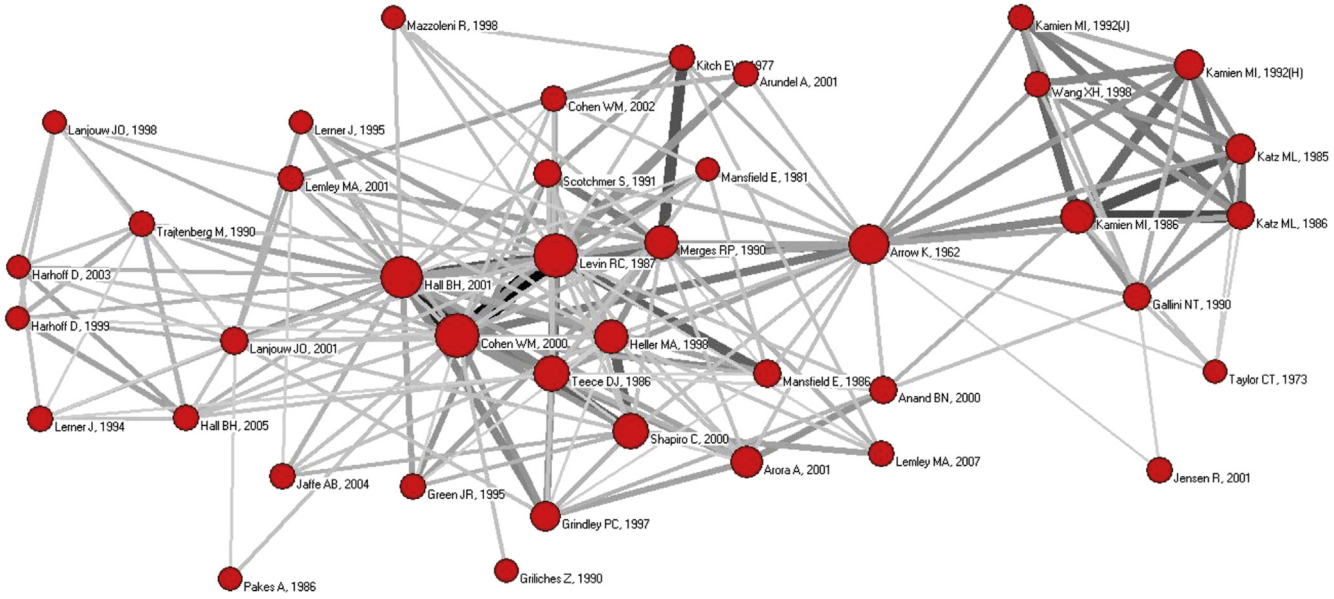

Fig. 6. Co-citation network diagram – late period (2000–2012).

our sample were published in technology management journals, economics journals, general management journals, and law review journals. Academic journals with a focus on IP management would serve as a platform for rich discussions among researchers and inspire future research directions. The lack of such journals hinders the development of the concepts, shared language, and knowledge structures of IP management [81]. Therefore, we believe that it is essential to have impactful academic journals and conferences in the field of IP management in order to form a community that is conducive for the field's development.

Thirdly, we identified the most frequently cited references by IPM articles. For those who are new to the field, this may serve as an appropriate reading list to begin with. For experienced researchers and practitioners, it is also crucial to look back and develop a more comprehensive view of the underlying knowledge structure.

Furthermore, the co-citation patterns uncovered in this study provided a clear picture of the intellectual structure of the field. In the network diagrams, different groups of studies emerged with emphases on different aspects of IP management. The network analysis revealed the centralized position of studies on appropriability provided by IP and firms' patenting propensity. Since one of the basic functions of intellectual property rights is to enable firms to better appropriate from their innovation efforts, these topics remain central themes in the current IPM research. The group of studies on the openness of IP strategies emerged next to the center and is currently an especially heated topic. Other research topics located at the fringe of the network included IP valuation, optimal IP licensing strategy, and economic impact of patent systems. Licensing and valuation remained two important aspects of current IPM research, while the popularity of economic impact and function of IP systems has faded over the years. In addition, by dividing the sample into two periods, we were able to observe how the field evolved over the years and changes in its knowledge base. Earlier studies on IP management were found in economics studies, while more firm-level studies were conducted in the recent decade, drawing upon the management literature.

This study performed a comprehensive bibliometric review of the IP management research. By performing a citation and co-citation analysis on a large sample of IPM articles, we bridged the gap left by the previous qualitative reviews and provided researchers with a better understanding of the body of knowledge of this field.

6.1. Limitations

The findings of this paper need to be interpreted with several limitations in mind. Firstly, the use of bibliometric methods has some inherent weaknesses. Citation and co-citation analysis are based on the premise that authors cite previous work they consider to be crucial for their own research development. In some situations, however, articles may be cited for various other reasons and citations may not reflect actual knowledge transfer or intellectual contribution [82]. In this study, we used a sample consisting of 773 source articles, which we believe could alleviate the aforementioned concern to an acceptable degree. Moreover, since we focused on the most cited and co-cited papers, the influence of such bias would not be prominent and citation data could still be regarded as a reliable indicator of intellectual contribution and knowledge relatedness.

Secondly, the selection of the source articles has certain deficiencies. No search criterion is perfect and able to cover all related articles. We attempted to make up for this deficiency and improve the coverage of our sample to an acceptable degree. We first consulted four IPM scholars and practitioners before deciding on the search keywords. We then took efforts to cross-check three journals for articles not covered by our search method. After these procedures, we believe our sample — although not perfect — is comprehensive enough to provide insights on the current status and intellectual structure of the research field.

Lastly, our division of the two periods is somewhat arbitrary. Others may have different opinions on how the sample should be divided. We chose the year when the number of IPM studies grew the fastest as the dividing point, rather than dividing the sample into equal sizes. The objective of dividing the sample was to observe the changes in the knowledge structure of the research field and our dividing method enabled us to achieve this goal. Therefore, we believe our dividing method is appropriate in this context.

6.2. Implications for future research

Further research could be done to study the field of IPM using bibliometric methods. For example, future studies may choose to focus specifically on IPM dedicated journals (*WPI*, *JIPR*, *IJIPM*, etc.). Citation and co-citation analysis could be used to trace the development of these journals and how their body of knowledge evolves over time. Another approach is to study the most cited and co-cited authors by IPM papers. Special attention could be paid to investigate the reason why they are highly cited, what contributions they have made to the research field, the backgrounds of these authors, and other areas in which they publish their work. We hope to see more bibliometric studies of this type in the future as the field continues to evolve.

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