A Survey of Intellectual Property Rights Literature from 1971 to 2012: The Main Path Analysis

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Abstract--**Intellectual property rights (IPRs) protection is strategically crucial for multinational corporations which are heavily conducting technology innovation to keep their technological superiority, competitiveness, and return of innovation investment. Developed countries are concerned that unequal protection of IPRs may result in a significant loss through unauthorized imitation in other countries while developing countries think that stronger IPRs would increase the costs of technology acquirement and raise the price of consumer products. The differences in IPR policies have led to significant disputes in international trade. Over the past four decades many researchers have investigated various issues regarding the protection of intellectual property rights.**

This paper adopts a unique approach to review the development trajectories of IPR research over the past four decades. We use ISI web of science (WOS) as the data source to retrieve the related literature and their citation data, and then apply the main path analysis on the citation data to identify the key-route main paths of the citation-based network. A total of 3184 papers and their citation data were retrieved and analyzed. The key-route main path discloses three different focuses on the research of IPRs – the scope of the patents, the preferences of the North and the South, and patent reform.

I. INTRODUCTION

The protection of intellectual property rights (IPRs) is strategically crucial for multinational corporations (MNCs) to keep their technological superiority, competitiveness, and return of innovation investment. Developed countries are concerned that unequal protection of IPRs may result in significant losses through unauthorized imitation in other countries while developing countries may consider that stronger IPRs would increase the costs of technology acquisition and raise the price of consumer products. The differences in IPR policies have led to significant disputes in international trade.

Many researchers have investigated the issues of IPRs over the past few decades. It is time to take a complete survey of the published literature to understand the knowledge diffusion paths and evolutionary trajectories in this field. We use the ISI Web of Science (WOS) as a data source to retrieve the relevant papers and their citation data. We carefully choose the keywords and set the data time span ranges from 1971 to 2012 to search the relevant papers. A total of 3184 papers and their citation data were retrieved, and then a citation network is generated. A proprietary program is applied on the citation network to explore the key-route main path, and a freeware Pajek is used to visualize the results.

Through above-mentioned procedure, the topics that prior researchers have focused on at different time periods are clearly identified. We also list the most influential papers/authors that play an important role in the knowledge diffusion of IPRs and brief the concepts that they proposed. We believe that the methodology used and the results concluded in this study are very helpful for those who are interested in understanding the development trajectories of IPR research.

II. METHODOLOGY

This study adopts a citation-based network analysis to investigate the knowledge diffusion structure of the intellectual property rights literature. Acedo *et al*. [4] recommended that analyzing the references of a set of scientific papers makes it possible to identify a group of papers belonging to the same school, paradigm, or theory, and explore the knowledge diffusion and theory development trajectory of the targeted scientific field. Prior researchers have demonstrated that the main path analysis is a proper method for accomplishing this task.

Hummon and Doreian [20] proposed to trace only the 'main path' to identify the major development trajectory of a scientific field. This is done by first establishing the importance of each link in a citation network and then finding out the path that connects the important links. Hummon and colleagues applied the method to a citation network of the centrality-productivity literature [21] and to the social network analysis field [19]. Batagelj [6] enhanced the main path analysis by providing various algorithms for calculating the significance index of citation links and suggested that the search path count (SPC) is a good choice.

Many research studies have applied main path analysis to explore technological development trajectories, using not only bibliographical citation data but also patent citation data. Mina *et al*. [32] adopted both bibliographic and patent citation data to reveal the growth and transformation of coronary artery disease treatments. Verspagen [38] used patent citation data to identify the development trajectories of fuel cell technology. Harris *et al*. [17] reviewed the literature on secondhand smoke and applied the main path analysis to identify the gap between discovery of risk factors and delivery of interventions. Liu and Lu [26] used the main path analysis to identify the knowledge diffusion path of the resource-based theory and applied the multiple global and key-route main path approaches to explore more information.

Following a similar approach that Liu and Lu [26] used, we adopt a key-route main path analysis to survey the

literature for field IPRs. The search procedure for the key-route main paths is as follows. First, we locate links with the highest SPCs in the network as the target links. The number of target links decides the level of detail one wants to uncover. By taking Fig. 1 as an example, if one aims at only the highest SPC links, then four links (B-D, C-E, E-G, and E-H) are chosen. If the top two SPCs are targeted then three additional links A-C, B-C, and F-I are selected. Second, one searches from the end node of a target link to find the most significant path forward and then searches from the beginning node of the same link to find the most significant path backward. Third, one combines the results of both the forward and the backward searches into one path to form a key-route path. Fourth, one goes back to the second step to work on the remaining target links until all of them are taken care of. For example, if one wants to find the key-route local main path with the highest SPC, then B-D, C-E, E-G, and E-H are selected. When applying a local method (selecting the highest SPC links from each node), B-D-E-G and B-D-E-H are identified from route B-D, and A-C-E-G, A-C-E-H, B-C-E-G, and B-C-E-H are identified from routes C-E, E-G, and E-H. Combining the results, A-C-E-G, A-C-E-H, B-C-E-G, B-C-E-H, B-D-E-G, and B-D-E-H are assembled as the key-route local main path.

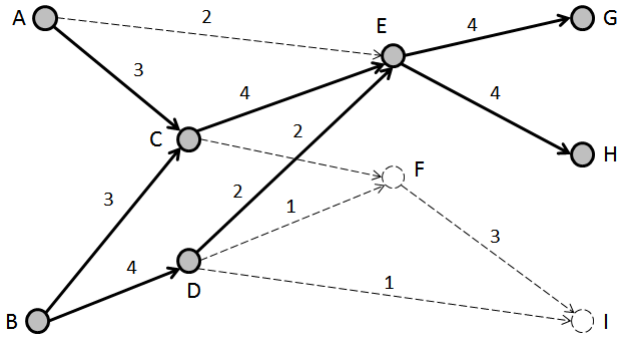

Fig. 1. The key-route main path (marked with solid lines), numbers on the links are SPCs.

III. DATA

We use the ISI Web of Science (WOS) as the data source to retrieve the relevant articles. The WOS is a citation database with multidisciplinary coverage of high impact journals in science, social sciences, and international proceedings for conferences. Databases selected for this study are the Science Citation Index Expanded (SCIE), the Social Sciences Citation Index (SSCI), the Conference Proceedings Index-Science (CPI-S), and the Conference Proceedings Index-Social Science and Humanities (CPI-SSH).

The keywords used in the query are “intellectual property rule?”, “intellectual property right?”, “patent protection”, “patent portfolio”, “patent litigation”, “patent exploitation”, and “patent system*”.

The data time span ranges from 1971 to 2012. We removed the articles, which were from anonymous sources, and those articles that are not in our research scope. In total, 3184 articles were included in the data set for further investigation.

A. Basic Statistics

To identify the influential journals and authors that made significant contributions in the field of IPR, we list the data of the total number of papers, g-index, h-index and active years of the top 10 journals and authors in Tables 1 and 2.

Table 1 shows that *Research Policy* has published the most number of papers and is far ahead of the other journals. This journal is also the number one in the g-index and h-index rankings, followed by *Journal of International Economics, RAND Journal of Economics, American Journal of Agricultural Economics* and *Journal of Development Economics*. In Table 1, we can find that the journals in the economics category have published the highest volume of articles in IPR research. Some journals have published many IPR papers but the g-index and h-index are not high enough to be listed in the top ten journals, such as the *IIC-International Review of Industrial Property and Copyright Law* and *IIC-International Review of Intellectual Property and Competition Law*.

TABLE 1. JOURNAL STATISTICS

Total papers	g-index	h-index	Active years	Journal name
80	49	27	1974~2012	*Research Policy*
25	25	12	1991~2012	*Journal of International Economics*
21	21	15	1989~2012	*RAND Journal of Economics*
23	18	10	1983~2009	*American Journal of Agricultural Economics*
17	17	11	1994~2011	*Journal of Development Economics*
24	17	9	1992~2012	*International Journal of Industrial Organization*
16	16	12	1995~2011	*Stanford Law Review*
16	16	9	1986~2011	*Science*
15	15	8	1976~2010	*World Development*
24	14	9	2000~2012	*Journal of International Economic Law*

Note: The journals are listed according to the order of the g-index followed by the h-index.

Table 2 shows that Maskus and Lemley are the top two authors that had the greatest contributions in the IPR research work. They also led in the g-index and h-index rankings, followed by Park, Abramowicz, and Eisenberg.

Table 3 summarizes the statistics of the IPRs papers in the top 10 categories (subject areas). It shows that these IPR studies are mostly categorized under the "Business & Economics" and "Government & Law" categories, implying that they are contributed largely by researchers in the business, economics, government, and law disciplines.

IV. RESULTS

When we set the number of key route analysis as 30, a clear picture of IPRs development is observed. Please refer to Fig. 2. The articles in the upper left section discuss the scope of the patent, including the length, width and height. The papers in the upper right portion examine the different preferences of patent protection from the North and the South. After 2000, researchers switched their focus on the issues of patent policy and reform. We discuss the details of these three focuses in the following paragraphs.

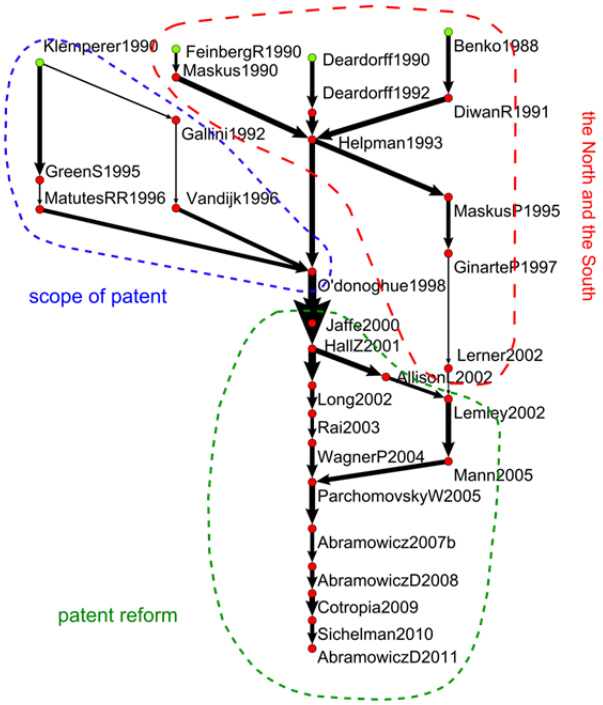

Fig. 2. Key-route main path

TABLE 2. AUTHOR STATISTICS

Total papers	1st authors	g-index	h-index	Active years	Name
18	13	18	10	1990~2012	Maskus, KE
16	12	16	10	1997~2012	Lemley, MA
9	5	9	5	1996~2012	Park, WG
8	8	8	7	2003~2011	Abramowicz, M
8	7	8	6	1992~2011	Eisenberg, RS
8	8	8	5	1971~2005	Barton, JH
8	2	8	4	2002~2012	Saggi, K
7	3	7	5	1998~2008	Lai, ELC
7	5	7	5	1998~2005	Lanjouw, JO
7	3	7	5	1997~2009	Moschini, G

Note: The authors are listed in the order according to the g-index followed by the h-index.

TABLE 3. CATEGORY STATISTICS

Category	Number of papers
Business & Economics	1104
Government & Law	674
Engineering	258
Public Administration	201
Computer Science	139
Agriculture	131
Chemistry	125
Biotechnology & Applied Microbiology	117
Social Sciences	114
Pharmacology & Pharmacy	132

Note: A paper may belong to multiple categories.

A. Scope of patents

Before 2000, the scope of patent protection was one of the hot research topics in the IPR field. Researchers discussed how broad the scope of patent protection should be, including the issues of length, breadth, width and height.

Klemperer [23] argued that the consensus of the length (lifetime) of a patent has been achieved among different countries, but not on the width (scope of coverage) of the patent. He analyzed the trade-offs between patent length and width to answer what forms of patents yield the patent holder's profits with the lowest social costs. He showed that under what conditions long-lived but very narrow patents are the social efficient way to reward innovations and under what conditions short-lived but very broad patents are optimal. Gallini [13] argued that the longer the patent life, the more likely the rivals invent around the patented products. She found that the optimal patent lengths are sufficiently short to discourage imitation. With both patent length and breadth (cost of imitation) as instruments, the optimal policy does not allow imitation with patent lengths adjusted to achieve the desired rewards.

Van Dijk [37] stated that the stringency of novelty requirements used in judging patentability defines the height of patent protection. He showed that a patent holder can lose with medium patent heights, but not with higher patent protection. The non-patent-holder can gain with medium heights but is increasingly worse off if patents provide high protection. Matutes et al. [31] argued that the scope (applications of the basic innovation) protection is more efficient in reducing the dynamic social inefficiency than the length protection. They found that scope protection generates a higher level of social welfare because rivals can introduce applications earlier and the patent holder has more flexibility to decide when to exercise the patent rights. The optimal patent protection system should induce early disclosure of fundamental innovations while still preserving firms' incentive on R&D investment, and increase the rivalry in the markets for applications.

Green and Scotchmer [15] claimed that innovators of derivative improvements may erode the initial innovator's profits in the market with sequential innovation. They investigated the profit division in sequential innovation and suggested that patents should last longer when a sequence of innovations is not concentrated in one firm but undertaken by different firms. The most effective policy is ensuring that the first innovator earns a large share of profit from the second-generation products it facilitates. O'Donoghue [33] investigated patent protection for sequential innovations. He proposed the concept of patentability requirements as a minimum innovation size required to get a patent to stimulate R&D investment and increase dynamic efficiency. The requirement can push firms to pursue larger innovations to extend market incumbency and increase the rewards.

B. The preferences of the North and the South

In the upper right portion of Fig. 2, researchers discussed the different preferences on patent protection between the North and the South. The North represents the innovating economies, including the United States, the European Community, Japan, etc. The South stands for those developing countries with few innovative products. These two regions have different preferences on intellectual property protection.

Benko [7] stated that the United States recognizes that the country's past success was heavily based on technological superiority. The liberal policies on technology transfer have given away the country's principal resource. Hence the issues of international protection of IPRs should be seriously investigated, including the ownership and control of technology, and the effects of ownership on the dynamic process of technological change. In the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), an international agreement on IPRs was one of the major goals to solve the international differences in IPR policies. Maskus [29] argued that IPRs are society's attempt to achieve a balance in the tension among information providers and users. IPRs allow creative interests to extract a return on investments in exchange for making available new technologies and products. Both producers and consumers benefit from IPR protection. Feinberg and Rousslang [12] used data of U.S. firms in five industry sectors to examine the static welfare changes caused by foreign infringement of U.S. IPRs. They found that infringement caused profit losses in legitimate U.S. suppliers for greater than 1% of their total sales. The gains to the consumers are more than half of the losses from legitimate producers. And finally, the losses of the producers exceed the profits of the infringers.

Some researchers examined the North-South issues via the equilibrium theory. Diwan and Rodrik [11] argued that the North and the South have different distributions of preferences over the range of exploitable technologies. They conducted numerical simulations and found that when the technological preferences of the two countries become more similar, the level of patent protection provided by the South was reduced. Furthermore, when the relative market size of the South is increased, the South enhances its patent protection. Helpman [18] used a dynamic general equilibrium framework, in which the North invents new products and the South imitates them, to evaluate the effects of the enforcement of IPRs and concluded that a policy of tighter IPRs is harmful to the South. Maskus and Penubarti [30] adopted a static general-equilibrium trade model to investigate whether different patent laws influence international trade. They found that, greater than expected, stronger patent laws attract flows of imports from the OECD economies into both small and large developing economies.

Some researchers argued that tighter patent protection is unfavorable to developing economies. Deardorff [9] argued that patent protection is almost certain to redistribute welfare away from developing countries, and therefore patent protection should not be extended to all developing countries. More liberal trade policies will enhance the welfare of

developing countries. He further used a model of invention and patent protection to examine the welfare effects of extending patent protection from an inventing country to another country that is only a consumer of invented products [10]. The results show that extending patent protection to a larger portion of the world is beneficial to the inventing countries, but the welfare of the world as a whole becomes negative. At least the very poorest countries should be exempted from patent protection extended under the GATT. Helpman [18] also concluded that if anyone benefits from tighter IPRs in less developed countries, it is not the South.

Ginarte and Park [14] analyzed the indexes of patent rights for 110 countries over the period 1960 to 1990 to examine what factors determine how strongly patent rights will be protected. They found that the country's level of R&D activity, market environment and international integration affect patent protection levels. More developed economies are more likely to provide stronger protection. When a nation's research sector reaches a critical size, R&D activity influences patent protection levels. The results implicate that it is important to foster a significant research base in those countries with weak IPR protection and thereby create incentives for protecting patent rights. Lerner [25] examined the explanations for variations in the strength of patent protection across 60 countries over a 150-year period. Wealthier countries are more likely to allow a longer time of patent validity and to ratify treaties assuring equal treatment from other countries. The origin of a nation's commercial law plays an important role in explaining the existence of limits on a patentee's privileges and discriminatory provisions against foreign patentees.

C. Patent reform

After 2000, many researchers put their efforts on examining the issues of patent policy, practices and reform. Some of them focused on the patenting in the U.S. Jaffe [22] surveyed the major changes in patent policy and practice in the U.S. over the time period of 1980 to 2000. He concluded that the relationship between technological innovation and changes in patent policy is not significant. However, the extension of patent protection to publicly funded research has a significant impact in technology transfer. To verify whether semiconductor firms heavily rely on patents to gain appropriate returns to their R&D, Hall and Ziedonis [16] examined the patenting behavior of 95 U.S. semiconductor firms from 1979 to 1995 and found that in the 1980s, strengthening of the U.S. patent rights spawned patent portfolio races among capital intensive firms, and it also facilitated the entry of specialized design firms.

Some researchers have investigated patent strategy from various aspects, such as patent policy for standard-setting organizations (SSOs), patent portfolio, etc. Lemley [24] studied the patent policy of dozens of SSOs and found that interface standards are much more prevalent in the computer networking and telecommunications industries than in other fields. The government can enforce these private ordering agreements and avoid unduly restricting SSOs by overzealous antitrust scrutiny. Parchomovsky and Wagner [35] found that the true value of patents lies not in their individual worth, but in their aggregation into a collection of related patents -- a patent portfolio. Patent portfolios simultaneously increase the scale and the diversity of available marketplace protection for innovations.

Numerous researchers discussed the issues of patent system reform. Allison and Lemley [5] compared 1000 U.S. patents issued between 1996 and 1998 with a similar sample issued between 1976 and 1978 to obtain a clear picture of how the patent system has changed over time. They found that the patents issued in the late 1990s are more complex and more heterogeneous than those issued in the late 1970s. Patent litigation is especially likely to occur in the biotechnology and pharmaceutical industries. Litigated patents on average cite more prior art, have more claims, and spend longer time in prosecution than ordinary patents. Patent owners in the semiconductor and electronics industries frequently engage in royalty-free cross-licensing. Heterogeneity has significant implications for patent system reform. Rai [34] argued that due to the interdependence of the various institutions within the patent system, the reform of the system must be both multi-institutional and closely related to the institutional competence of the actors. He suggested that Congress should endow the system with improved fact-finding expertise through the institution of specialized trial courts. A balanced patent system should position the Federal Circuit on formulating patent policy, bolster the fact-finding expertise of inferior institutions' abilities, and institute additional appellate mechanisms.

Wagner and Petherbridge [39] assessed the performance of the court against its basic premise -- centralization of a legal authority in the Federal Circuit will yield a clearer and more predictable legal infrastructure for patent law. They found that the basic methodological approach to claim construction leads to distinct results in the Federal Circuit. Moreover, the composition of the three-judge panel that hears and decides on the case can affect the claim construction analysis. The findings can be a good reference for procedural and jurisprudential reform.

Some researchers highlighted various suggestions for patent system reform, such as how to reduce the problem of patent underdevelopment, are market experimentations worthwhile for an exclusivity grant, decoupling the invention and commercialization functions, and how to refine the induced standards of a non-obviousness doctrine, etc.

To reduce the risk of patent underdevelopment, Abramowicz [1] argued that patent terms should demonstrate a substantial degree of achievement before patenting. He proposed a patent extension auction system to allow a patentee to request an auction, but it could be won only by substantially outbidding third parties. Under this system, patentees would call for auctions only when the benefits of ownership continuity are relatively high. To eliminate the problems of too many patent applications, excessive patents,

underdevelopment of patented technology, increased assertion of patent rights, and fuzzy patent boundaries, Cotropia [8] suggested that a patent application should demonstrate the achievement of its claims and provide a development timeline.

Abramowicz and Duffy [2] argued that a first entrant into the market reveals the information about consumer demand and market feasibility to other firms. Modern IPR systems provide exclusive rights to technological discoveries but pay little attention to information arising from market experimentation. They suggested that market exclusivity can promote earlier market entry and increase the level of entrepreneurial activity in the economy.

Sichelman [36] contended that the patent system is substantially retarding the commercialization of valuable inventions. He suggested that decoupling the invention and commercialization functions of patent law into dual rights would yield more commercialization than the existing patent system, without decreasing competition, encouraging rent-seeking, or increasing administrative costs.

In the Graham v. John Deere Co. case, the Supreme Court explained that the non-obviousness doctrine of patent law implies "those inventions which would not be disclosed or devised but were for the inducement of a patent." Abramowicz and Duffy [3] argued that the induced standard of patentability should serve as the doctrinal polestar. They offered several refinements to the induced standard and suggested that the Patent and Trademark Office and courts could implement the inducement standard in an administrable way.

Some researchers investigated the patent system from an informational perspective. Long [27] argued that patents reduce informational asymmetries between patentees and observers in capital markets, thereby potentially reducing information costs. The informational function of patents may be more valuable to the rights holder than the substance of the rights. A firm can use the patent portfolio as a credible indicator of the firm's quality. Mann [28] also confirmed that the informational benefits can improve the innovation system. He found that patents are more beneficial to small firms than to large firms. For small firms, copyrights and trade secrets are not useful mechanisms as compared to patents to appropriate the value of their inventions except in preventing piracy. The benefits of excluding competitors are limited for firms that cannot exploit the relevant patents themselves. The benefits of patent use in cross-licensing is substantial to firms that obtain the patents but not to the industry as a whole.

V. CONCLUSIONS

This study uses a unique approach, the key-route main path analysis, to survey the literature of IPRs published from 1971 to 2012. The results show that before 2000, international patent systems were under construction, and one group of researchers focused their efforts on discussing how broad the scope of patent protection should be. The other group of researchers examined the different preferences of the North and the South and how to balance the differences between them. After 2000, researchers found that there are many shortcomings in the existing patent system. They provided many suggestions to refine the grant procedure or reposition the institutions within the patent system.

This paper demonstrates that the main path analysis is a good approach for exploring the evolutionary trajectories of a specific field. A newcomer can apply this approach to quickly obtain a clear picture for the development in a targeted field.

ACKNOWLEDGMENTS

The authors thank the financial support from Taiwan's National Science Council grants NSC 102-2632-H-155-001-MY3 and NSC 102-2410-H-011-008-MY3.

REFERENCES

[1] Abramowicz, M.; "The danger of underdeveloped patent prospects," *Cornell Law Review*, vol. 92, no. 6, pp. 1065-1121, 2007.

[2] Abramowicz, M. and J. F. Duffy; "Intellectual property for market experimentation," *New York University Law Review*, vol. 83, no. 2, pp. 337-410, 2008.

[3] Abramowicz, M. and J. F. Duffy; "The Inducement Standard of Patentability," *Yale Law Journal*, vol. 120, no. 7, pp. 1590-1680, 2011.

[4] Acedo, F. J., C. Barroso and J. L. Galan; "The resource-based theory: Dissemination and main trends," *Strategic Management Journal*, vol. 27, no. 7, pp. 621-636, 2006.

[5] Allison, J. R. and M. A. Lemley; "The growing complexity of the united states patent system," *Boston University Law Review*, vol. 82, no. 1, pp.77-144, 2002.

[6] Batagelj, V.; "Efficient algorithms for citation network analysis," *University of Ljubljana, Institute of Mathematics, Physics and Mechanics, Preprint series*, vol. 41, p. 897, 2003.

[7] Benko, R. P.; "Intellectual property-rights and the Uruguay Round," *World Economy*, vol. 11, no. 2, pp. 217-231, 1988.

[8] Cotropia, C. A.; "The folly of early filing in patent law," *Hastings Law Journal*, vol. 61, no. 1, pp. 65-129, 2009.

[9] Deardorff, A. V.; "Should patent protection be extended to all developing countries," *World Economy*, vol. 13, no. 4, pp. 497-507, 1990.

[10] Deardorff, A. V.; "Welfare effects of global patent protection," *Economica*, vol. 59, no. 233, pp. 35-51, 1992.

[11] Diwan, I. and D. Rodrik; "Patents, appropriate technology, and North South trade," *Journal of International Economics*, vol. 30, pp. 27-47, 1991.

[12] Feinberg, R. M. and D. J. Rousslang; "The economic-effects of intellectual property right infringements," *Journal of Business*, vol. 63, no. 1, pp.79-90, 1990.

[13] Gallini, N. T.; "Patent policy and costly imitation," *RAND Journal of Economics*, vol. 23, no. 1, pp. 52-63, 1992.

[14] Ginarte, J. C. and W. G. Park; "Determinants of patent rights: A cross-national study," *Research Policy*, vol. 26, no. 3, pp. 283-301, 1997.

[15] Green, J. R. and S. Scotchmer; "On the division of profit in sequential innovation," *RAND Journal of Economics*, vol. 26, no. 1, pp. 20-33, 1995.

[16] Hall, B. H. and R. H. Ziedonis; "The patent paradox revisited: An empirical study of patenting in the US semiconductor industry, 1979-1995," *RAND Journal of Economics*, vol. 32, no. 1, pp. 101-128, 2001.

[17] Harris**,** J. K., D. A. Luke, R. B. Zuckerman, and S. C. Shelton; "Forty years of secondhand smoke research: the gap between discovery and

delivery," *American Journal of Preventive Medicine*, vol. 36, no. 6, pp. 538-548, 2009.
[18] Helpman, E.; "Innovation, imitation, and intellectual property-rights," *Econometrica*, vol. 61, no. 6, pp. 1247-1280, 1993.
[19] Hummon, N. P. and K. Carley; "Social networks as normal science," *Social Networks*, vol. 15, no. 1, pp. 71-106, 1993.
[20] Hummon, N. P. and P. Doreain; "Connectivity in a citation network: the development of DNA theory," *Social Networks*, vol. 11, no. 1, pp. 39–63, 1989.
[21] Hummon, N. P., P. Doreian, P. and L. C. Freeman; "Analyzing the structure of the centrality-productivity literature created between 1948 and 1979," *Science Communication*, vol. 11, no. 4, pp. 459-480, 1990.
[22] Jaffe, A. B.; "The US patent system in transition: policy innovation and the innovation process," *Research Policy*, vol. 29, pp. 531-557, 2000.
[23] Klemperer, P.; "How broad should the scope of patent protection be," *RAND Journal of Economics*, vol. 21, no. 1, pp. 113-130, 1990.
[24] Lemley, M. A.; "Intellectual property rights and standard-setting organizations," *California Law Review*, vol. 90, no. 6, pp. 1889-1980, 2002.
[25] Lerner, J.; "150 years of patent protection," American Economic Review, vol. 92, no. 2, pp.221-225, 2002.
[26] Liu, J. S. and L. Y. Y. Lu; "An integrated approach for main path analysis: The development of the Hirsch index as an example," *Journal of the American Society for Information Science and Technology*, vol. 63, no. 3, pp. 528–542, 2012.
[27] Long, C.; "Patent signals," *University of Chicago Law Review*, vol. 69, no. 2, pp. 625-679, 2002.
[28] Mann, R. J.; "Do patents facilitate financing in the software industry?" *Texas Law Review*, vol. 83, no. 4, pp. 961-1030, 2005.
[29] Maskus, K. E.; "Normative concerns in the international protection of intellectual property-rights," *World Economy*, vol. 13, no. 3, pp. 387-409, 1990.
[30] Maskus, K. E. and M. Penubarti; "How trade-related are intellectual property-rights," *Journal of International Economics*, vol. 39, pp. 227-248, 1995.
[31] Matutes, C., P. Regibeau and K. Rockett; "Optimal patent design and the diffusion of innovations," *RAND Journal of Economics*, vol. 27, no. 1, pp. 60-83, 1996.
[32] Mina, A., R. Ramlogan, G. Tampubolon, and J. S. Metcalfe; "Mapping evolutionary trajectories: Applications to the growth and transformation of medical knowledge," *Research Policy*, vol. 36, no. 5, pp. 789-806, 2007.
[33] O'Donoghue, T.; "A patentability requirement for sequential innovation," *RAND Journal of Economics*, vol. 29, no. 4, pp. 654-679, 1998.
[34] Rai, A. K.; "Engaging facts and policy: A multi-institutional approach to patent system reform," *Columbia Law Review*, vol. 103, no. 5, pp. 1035-1135, 2003.
[35] Parchomovsky, G. and R. P. Wagner; "Patent portfolios," *University of Pennsylvania Law Review*, vol. 154, no. 1, pp. 1-77, 2005.
[36] Sichelman, T.; "Commercializing patents," *Stanford Law Review*, vol. 62, no. 2, pp. 341-411, 2010.
[37] Van Dijk, T.; "Patent height and competition in product improvements," *Journal of Industrial Economics*, vol. 44, no. 2, pp. 151-167, 1996.
[38] Verspagen, B.; "Mapping technological trajectories as patent citation networks: A study on the history of fuel cell research," *Advances in Complex Systems*, vol. 10, no. 1, pp. 93–115, 2007.
[39] Wagner, R.P. and L. Petherbridge; "Is the federal circuit succeeding? An empirical assessment of judicial performance," University of Pennsylvania Law Review, vol. 152, no. 3, pp. 1105-1180, 2004.