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Identifying potential users of technology for technology transfer using patent citation analysis: a case analysis of a Korean research institute

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Abstract
The purpose of this study is to examine whether patent citation analysis can be used for making decisions of technology transfer. More precisely, the authors of this paper are interested in the matter of identifying potential users of technology by patent citation analysis. Previous research relied on patents' keywords, and as a consequence it was difficult to implement in practice where organizations retain huge number of patents to transfer. In this study, we attempt to use IPCs instead of keywords. Our approach is to identify dominant IPC and sub-classes of an organization by applying co-classification analysis, and explore firms that cited the patents in the dominant IPC. Our view is that the organizations explored in this process can be potential users of technology. To verify our view, we examined the patents and technology transfer cases of two divisions in K Research Institute in Korea. The results show that our view was right only for a limited field. We suppose that the reasons may stem from technological characteristics and firm size effect. Therefore, we suggest that there should be further research considering technological characteristics and firm size.

Keywords Technology transfer · Patent citation · Co-classification · Path-dependence · Potential user

JEL Classification O32

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Introduction

Recognizing the strategic importance of science and technology in global economy, firms, organizations, and national governments have put emphasis on R&D during the last a few decades. countries such as Israel, Japan, and Finland have been annually spending over 3% of GDP on R&D activities, and Korea in 2014 topped in the league as its R&D expenditure touched 4.29% of GDP. (MSIP and KISTEP 2016) The overall amount of R&D investment also increased rapidly over to 60 billion dollars. As the investment increased, the performance of Korean firms, research institutes, and universities has increased dramatically.

However, whilst the amount of technologies developed increased, the use and commercialization of technologies are still unsatisfactory. For instance, Korea's 24 public research institutes produced 9656 patent applications in 2014, but the number of technology transfer in the same year was only 1557. About 83.9% of patents are left unused despite successful application according to a government report (JOINS 2013).

Until now, a number of studies have addressed the issue of technology transfer. Yang and Kim (2008) argue that the difficulties in technology evaluation, lack of experts or dedicated teams for technology transfer, insufficient information about technology user firm and the firms' future strategies. KIBO (2014) also shows that the information asymmetry between users and suppliers are the major sources of difficulties in technology transfer. Especially, they argue that the difficulties in identifying users of technology are major challenge in technology transfer. Kani and Motohashi's research on Japanese firms licensing activities also found that the difficulties in finding licensing partners is the primary factor for the imperfection of the technology market (Kani and Motohashi 2012). Even in the US, estimating market demand for specific technology is one of the main hurdles for US Federal Research Institutes' technology transfer (Schacht 2007). Therefore, identifying the needs and potential users of technologies may be critical issue for successful technology transfer.

This paper addresses the issue above—exploring the needs and potential users of technologies. More specifically, we are interested in using patent information in dealing with the issue. Our view is that patent information in a field (which is basically past information) can be used as a good indicator for the future needs of the technology field if path dependencies are considered, following Sanditov (2005) and Seok et al. (2015). Therefore, we might argue that potential users of technology can be explored or identified by analyzing patent information. This paper aims to examine our view above and attempt to draw implications for technology transfer.

Previous literature

Potential users of technology in this paper refer to individuals or organizations that might be in need of a technology and might have intention to acquire or license in the technology. In other words, they can be understood as potential customers of technology under the condition that technologies are traded in the market like as products (Arora and Gambardella 2010). Therefore exploring or identifying potential users of technology can be viewed as a marketing (of technology as a product) process to search for potential customers.

In the marketing literature, there are a few streams of study for identifying potential customers. One is often called target marketing or STP analysis which includes market segmentation, targeting, and positioning. According to Kotler and Keller (2006), firms embrace target marketing to focus on a number of customers instead of scattering efforts to mass customers. They suggest firms to identify distinct groups of customers who differ in their needs (market segmentation), select one or a few market segments (targeting), and provide distinct benefits to the groups (positioning). This literature focuses on groups.

Another stream studies purchase intention of customers. Purchase intention means 'the possibility that customers will plan or willing to purchase a certain product or service in the future (Wu et al. 2011).' This literature attempts to find factors influencing customers' purchase intention. Consequently its implications can be used for planning products and services, and also used for identifying potential customers. Some examples of factors influencing purchase intention include product information, quality, and prices (Kotler and Keller 2006); product involvement (Blackwell et al. 2001); word-of-mouth (Mahajan et al. 1984); trust and prior experience (Mohamed et al. 2013), and etc. This literature focuses on individuals and their behavior.

The marketing literature may provide some insights for the purpose of this paper. However, there are some differences between the technology market and the consumer market (of the marketing literature). Whilst products in the marketing literature are traded mostly in B2C (business to consumer) markets, technologies may be traded in other types of markets; for instance, B2B (business to business) or any other forms. The tacit and context specific nature of technologies, which make them less tradeable (Arora et al. 2001), should also be considered. Although technology becomes less tacit and therefore more tradeable if it is patented, technology itself is still context-specific as it is to be used in the production of specific products. Due to these differences, the methods and processes suggested by marketing literature cannot be directly used for the trade of technologies.

There is a number of research addressing the matter of technologies trade. Some of them study the factors influencing technology licensing from the perspectives of technology-holders and technology-users. The factors from the technology-holders' perspective include appropriability regime, fragmentation of downstream market, firms size, the characteristics of technology and etc. (Teece 1986; Arora and Fosfuri 2003; Gambardella and Giarratan 2009); and those from the technology-users' perspective include not invented here (NIH) syndrome, absorptive capacity, and the relations between internal and external R&D (Arora and Gambardella 2010).

The factors above explain the conditions where technology transfers are enhanced, but their implications do not explain how to explore or identify potential users of technology. Some studies such as Kim (2009) show that appropriability regime of licensee country, familiarity through prior interaction, business similarity between partners, and prior independent experience as a licensor can be selection criteria for technology licensing partners. However, these selection criteria can be effectively used only when candidate users of technology are already presented.

Then how can we find potential users of technologies? To our knowledge, there are a number of approaches as presented below. Firstly, potential users can be found by simple survey. For instance, Lee et al. (2013) identified SME's technological needs for IT products by conducting a survey, and many other studies also rely on survey.

Secondly, there is an approach similar to market segmentation. For instance, there have been attempts to match between technology fields and industries. OECD constructed technology-industry concordance table (Johnson 2002), and Europe also implemented a similar work (Schmoch 2003). A Korean study (Kum and Ko 2011) linked international patent class (IPC) with Korean standard industry classifications, and utilized the result for identifying technology users. For another instance, Lichtenthaler (2010) suggested an approach of 'job-related' market segmentation instead of relying on demographic or product characteristics.

Thirdly, there is an approach using text-mining techniques. For instance, Seo et al. (2011) identified potential use of patents, and matched the uses with company names by text-mining.

However, the approaches above have some limitations. Survey sheets are randomly distributed, so respondents may be limited, and response rate may be low. For this reason, some significant or critical user needs may be omitted. In the case of concordance table, it is questionable whether industrial and technological evolution can be well reflected in the method. Lastly, text-mining techniques used by Seo et al. (2011) is too time-consuming, therefore it is lacking practical utility.

For this reason, Seok et al. (2015) suggested patent citation network analysis for technology transfer. Patent analysis has been widely used in many studies to show the flow of knowledge. It has been popular especially in the studies examining the knowledge flow between science and technology (Schmoch 2003; Alcacer and Gittelman 2006; Breschi and Catalini 2010). Even for the cases of technology transfer, patent citation analysis has been used to verify the effectiveness or efficiency of technology transfer (Hall and Helmers 2013; Agrawal and Henderson 2002; Almeida 1996).

To our knowledge, Seok et al's study is the first attempt to identify potential users of technology using patent citation analysis. The logic of their argument is as following. Patent citation is basically past information, so it may not be direct measure for present or (near) future technological needs. However, it should be considered that technological progresses are characterized by technological paradigms, trajectories, and path dependencies (Nelson and Winter 1977; Dosi 1982), and therefore future technologies can be shaped by past technological developments. If a firm cited a patent in the past, it may still be in need of same sorts of technologies and try to access them. Then patent citation information can be used as indicator for present or (near) future technology transfer when considering the path dependency of technology (Sanditov 2005).

Method

Seok et al.'s approach was much simpler to use, and their method was directly used for a research institute's technology marketing (according to an interview with one of the authors). However, the problem of their method is that it relies on keyword based search. It can be powerfully used when it is used for a single patent, but it is hard to implement at large organizational level. While large research organizations such as public research institutes usually retain a huge number of patents, the method requires keyword search for each patent. This makes the method still messy and difficult to implement in large organizations.

Therefore we suggest using patent classes (e.g. IPCs) instead of keywords. If an IPC can represent the overall technologies of an organization, taking the IPC instead of a huge number of keywords may make matters much simpler. However, just a single IPC may be too broad to identify a technology field. For this reason, we also suggest to use co-classifications to narrow the scope of technologies. Patents in many cases have multiple IPCs, so the patents characteristics can be more precisely identified by using co-classes of IPCs.

The detailed procedure of our approach is as following. Firstly, an IPC that represent an organizations overall technological fields will be identified. (The IPC representing the organization will be called dominant IPC.) We draw all the IPCs from the patents of an organization, and perform a co-classification analysis. This analysis will show what IPC is in the core of the organizations technologies. Secondly, we will examine what other IPCs are linked with the dominant IPC. The co-classifications of a dominant IPC and a sub-IPC may give us a more detailed picture of the technologies of the organization. Thirdly, we search patents which citing the patents in the co-classifications, and explore the names of applicants. The applicants are those cited the patents of the organization in the past. Considering path dependency, they may be still in need of technologies in the same (or similar) fields of technologies. Then we can regard these applicants as potential users of technology.

Following the procedure, we examine the patents and technology transfer cases of 2 research divisions of K Research Institute in Korea during 2004–2013 to verify this approach. K Research Institute is a government funded research lab specializing in chemistry. Among its 4 research divisions, we chose Division A and B. There are 2 reasons for this choice. Firstly, the divisions have compiled more patents than others, and the numbers of technology transfer and commercialization are higher than the other two. The Division A has 198 patents and transferred its technologies to 82 companies, whilst other divisions have 65–95 patents and transferred technologies to 29–41 companies. The Division B has 74 patents and 29 technology transfer cases which is similar to other divisions, but its revenue from technology transfer was 114 million KRW which is almost the same as the sum of the other three divisions'. Secondly, the patents and technologies of Division A are expected to be good cases. As this division concentrates on processes, technological life-cycle may be longer and technological environments can be more stable than others. In the case of Division B, it focuses on new drugs, so it can be compared with Division A's as its technologies may be mostly in the early stage in a technological life-cycle.

Regarding our method for analysis, there may be criticism that some free-to-use patent search systems can deliver similar result with our approach. According to (Jürgens and Clarke 2018), google patents (https://patents.google.com) can find relevant classes for entered keywords, and thematically group the result lists. It means that google patents (if used well) can make the first and the second stages (identifying dominant IPC and grouping by sub-IPCs) of our procedure unnecessary. Moreover, we admit that there may be more powerful and advanced techniques out there. However, whilst we try to analyse patents from two different divisions of K Research Institute, patent database do not necessarily show the 'divisions' information. Therefore we utilize our own method and the data set which was provided by the K Research Institute.[1]

The cases of K Research Institute

Division A (chemical processes)

Dominant IPC of the Division A's patents

We collected IPCs in the patents applied by the Division A of K Research Institute, and counted the frequency of occurrence. The frequency is shown in the Table 1 below.

[1] In addition, patent class systems such as IPCs and CPCs are already established technology classifications. We believe utilizing IPCs have some advantages over text- or keyword-based analyses (as well as disadvantages) such as simpler procedures and more systematic understanding of technologies.

Table 1 Frequency of IPC

IPC	Frequency	IPC	Frequency
B01J	61	C09B	2
C07C	39	G02C	2
B01D	16	H01L	2
C02F	16	A01N	1
C08J	16	A01P	1
C01B	14	A61P	1
C08G	11	B22F	1
B82Y	9	C03B	1
C10G	8	C07F	1
C07D	7	C08F	1
C08L	7	C08 K	1
B82B	6	C09C	1
C01F	6	C09K	1
C09D	6	C10L	1
C30B	5	C12N	1
B29B	4	C14C	1
E02B	4	C22B	1
A61K	3	C23C	1
B03C	3	D01F	1
B09B	3	D06P	1
C01G	3	F23G	1
C04B	3	G01N	1
B01F	2	G02B	1
C07B	2	H01B	1
C07K	2		

According to the table, B01J is the most frequently appearing code. This means that the patents of the division are mostly about "chemical or physical processes".

The frequency analysis above shows only simple count of IPCs, therefore it may not be enough to show how an IPC or a technology field is dominant in the division's patent pool. As a patent has multiple IPCs in many cases, it is relevant to perform a co-classification analysis. Figure 1 shows the network of co-classifications appearing in the patents of the division, and Fig. 2 presents the visual illustration of the network's betweenness centrality. In the Fig. 1, B01J is clearly in the center of the whole network, and has a dense network of linkages with other classes. In addition, B01J is still in the center of the Fig. 2, and it means that it is the closest node to all others. Considering the visual presentation of co-classification network and betweenness measure, it B01J is the dominant IPC, and the patents by Division A are mostly concentrated around the "chemical or physical processing" technology field.

Sub-IPCs of Division A's patents

B01J was identified as the dominant IPC in the previous section, and we attempted to find sub-IPCs of the technology field. All IPCs that co-occur with B01J in the patents by the

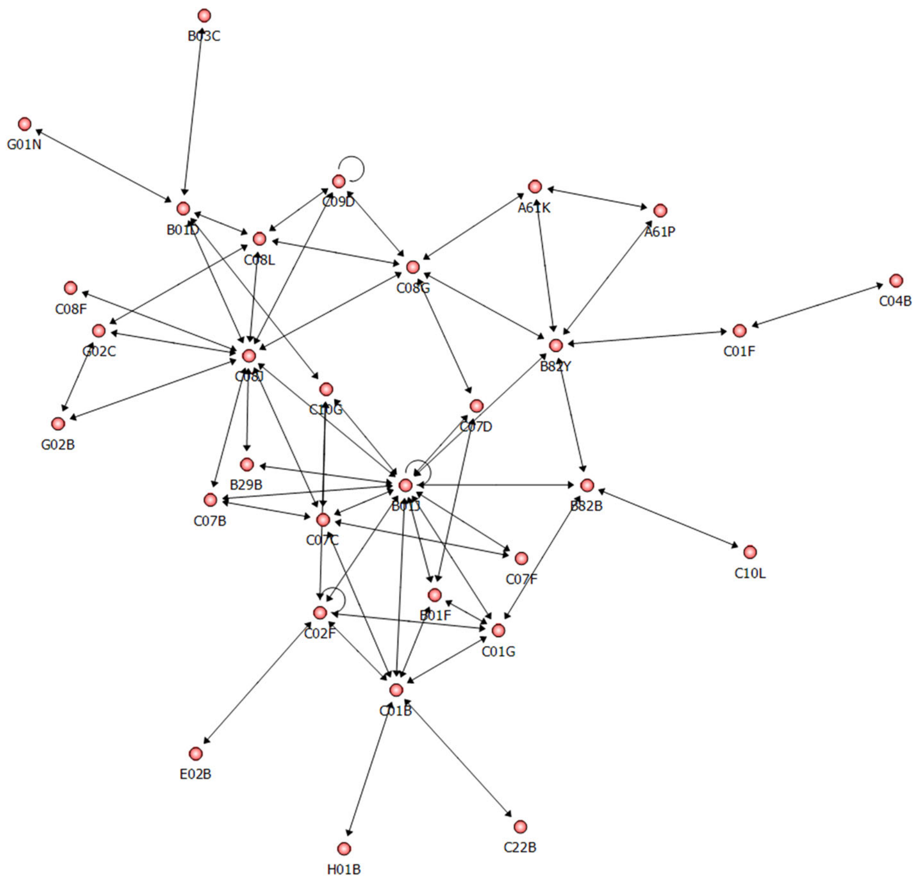

Fig. 1 Co-classification network of patents by the Division A

Division A were collected, and the closeness of the IPCs were measured as in the Table 2. While the closeness measure ranges from 0.52 to 0.6, the closeness of C01B, C07C, C08J, and B01F are slightly stronger than others. Considering the result of IPC analysis, the technology fields of the Division A are mostly about chemical or physical processes of non-metallic elements or compounds and acyclic or carbocyclic compounds; processing of organic compounds; and mixing processes (Table 3).

Forward citation analysis

We searched for the Korean patents which citing the patents with co-classification of B01J and sub-IPCs, and collected the names of the applicants of the citing patents. Using the data of the applicants of citing patents and the co-classification (of B01J and sub-IPCs) of cited patents, we performed a 2-mode network analysis and measured degree-centralities to explore which co-classifications are significant in terms of forward citation. The results are summarized in Fig. 3 and Table 4 below.

Figure 3 illustrates which co-classifications are linked with (or cited by) which applicants. The applicants appear in the figure can be regarded in our study as potential users of

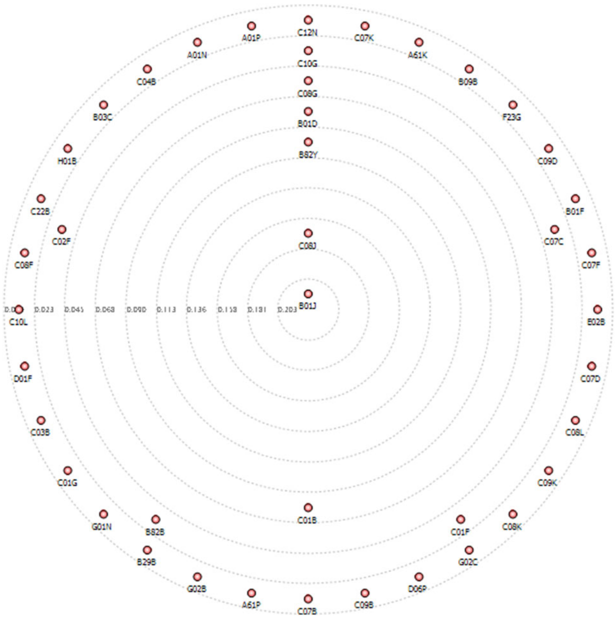

Fig. 2 Betweenness centrality of the network

Table 2 Closeness from the dominant IPC

IPC	Closeness
B01J	1
C01B	0.6
C07C	0.6
C08J	0.6
B01F	0.6
C07B	0.571429
C01G	0.571429
B82Y	0.545455
C07D	0.545455
B82B	0.545455
B29B	0.545455
C10G	0.521739
C02F	0.521739

technology. Some co-classifications have denser networks of linkages with many applicants than others have. These co-classifications may be the technology fields that are likely to be demanded by potential users, and therefore the possibilities of technology transfer are high.

The Table 4 shows co-classifications in terms of degree centralities. For instance, the degree centrality of B01J and C01B co-classification is the highest at 0.228829, and patents

Table 3 Descriptions of each IPC

B01J	Chemical or physical processes or their relevant apparatus
C01B	Non-metallic elements or their compounds
C07C	Acyclic or carbocyclic compounds
C08J	Working-up or general processes of compounding (of organic macromolecular compounds)
B01F	Mixing (e.g. dissolving, emulsifying, and dispersing)

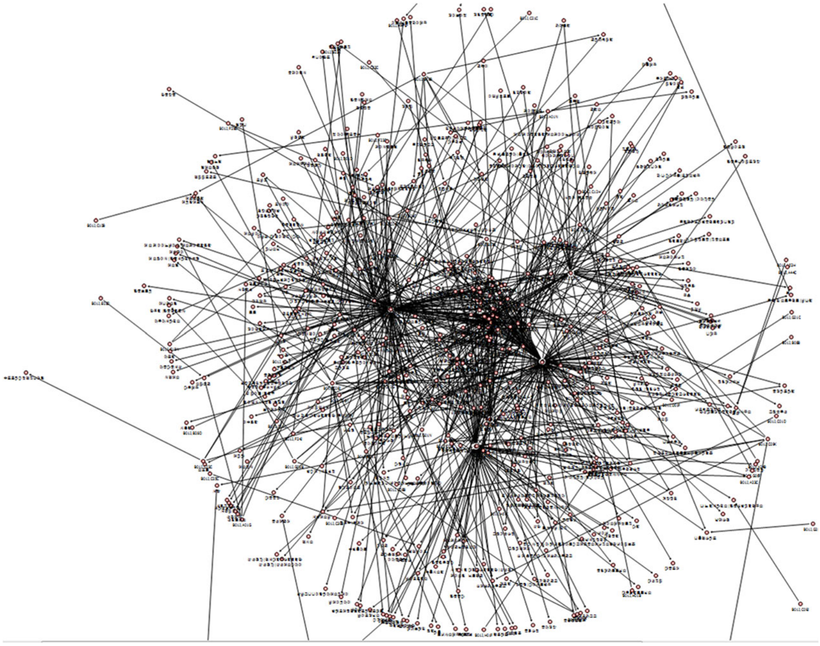

Fig. 3 2-mode network of cited co-classes and citing applicants

Table 4 Degree centrality

Co-classification	Degree centrality
B01J & C01B	0.228829
B01J & B01D	0.192793
B01J & C01G	0.111712
B01J & C02F	0.082883
B01J & C07C	0.077477
B01J & B82B	0.064865
B01J & C10G	0.045045
B01J & H01L	0.041441
B01J & F01N	0.037838
B01J & H01M	0.037838

which have B01J and C01B are highly likely to be transferred to technology users. It is worth pay attention on that the order of co-classification in Table 4 is different from the order of sub-classes in Table 2. Whilst Table 2 was drawn from the network of IPCs in the Division A's patents, Table 4 was from the 2-mode network of co-classifications and applicants (potential users). The IPCs in the Table 2 show the major fields of patents by the Division A, whilst the Table 4 shows forward citation of technology fields in general. In other words, Table 2 shows what the Division A does, and Table 4 shows which technologies are likely to be transferred to users. Therefore, the comparative importance of technologies by Division A may be different from the comparative importance of technology users' demand. However, as almost all IPCs in Table 2 appear in Table 4, Division A seems to have been carrying out what potential users have been demanded.

Potential users

Table 5 shows the names of organizations that were found in the forward citation analysis in the previous section. Among the co-classifications, Table 5 displays only 5 selected co-classifications for the purpose of presentation. There are 38 companies in B01J & C07C, 102 companies in B01J & C01B, 24 companies in B01J and C10G, 45 companies in B01J and C02F, and 58 companies in B01J and C01G.

Table 5 List of organizations citing the patents in the co-class (potential users)

Co-class	Organizations that citing the co-class patent
B01J and C07C	Gutz, Kumho Petrochemical, Nideck, Dasol Technology, DSME, Duksan Hi-metal, Toshiba, Dongyang Technology Development, Robert Bosch, Mui ENG, Samsung SDI, Samsung Electronics, Samsung Heavy Industries, Samsung Total, Seoho Metal, CQV, IT & C, Aekyung Petrochemical, SK Energy, SK Chemical, SK Telecom, SK Hynix, LG Electronics, LG Chemicals, Otis Elevator, Yuseong Tech, W User Company, WinTech, EMW, Infraware, Ji-in Steel, KCI, Tera Semicon, P&B, Delphi Korea, Hanrim Lodex, Hyundai Steel, Hyundai Heavy Industries (Total 38)
B01J and C01B	Green ENE, Geukdong Engineering, Dongmyung Construction Engineering, Glovit, Kumho Mitsui Chemical, Kumho Petrochemical, Kia Motors, Hyundai Motors, Saram&Nanum, Wonil Industries, Nau Construction, Naco Engineering, Daelim Industries, Daesung Electric, Daewoo IS, DSME, The Boeing Company, Dekist, Delko Korea, Toray AMK, Toshiba Samsung Storage, City and Forest, Dongbu Hi-Tech, Donyang Carbon, Dongwoo Fine Chem, Dongwha Construction, DMBH, Digi Entertainment, Raonsecure, Rust Chemical, Loreal, Lumens, Macronics International Company, Muyung Amex, BLT, Samsung Display, Samsung Mobile Display, Samsung SDI, Samsung LED, Samsung Electric, Samsung Electronics, Samsung Heavy Industries, Samsung Total, Seoul Semiconductor, Semes, Seiko Instrument, Soft Pixel, Shinsung, FA, Hyundai Heavy Industries, etc. (Total 102 Companies)
B01J and C10G	Digital Zone, etc. (total 24 companies)
B01J and C02F	Green ENE, etc. (total 45 companies)
B01J and C01G	Dasol Technology, etc. (total 58 companies)

Verification

Table 6 shows actual recipients of Division A's patents for the period of 2004–2013. Division A's patents in B01J class were transferred to 24 organizations. Among the cases, 11 were in B01J and C07C co-class, 5 were in B01J and C01B, and 8 were all others. The names of organizations are in the Table 5.

The comparison between Tables 5 and 6 yields the names of organizations which appear in both tables, and these are summarized in Table 7. These organizations are those identified as "potential users of technology", and also actual recipient of Division A's technology. In the case of B01J and C07C, 5 companies including SK Energy, Kumho PetroChemicals, Hyundai Heavy Industries, SK chemical, KCI, and Aekyung Petrochemical were actual recipients as well as potential users. In B01J and C10B, only 1 company (Hyundai Heavy Industries) was a recipient that can be found in the list of potential users. For other co-classifications, there was no company name that appears in both tables.

Division B (new drugs)

Dominant IPC of the Division B's patents

Using the same method with the case of Division A, we collected IPCs in the patents applied by the Division B of K Research Institute, and counted the frequency of occurrence. The frequency is shown in the Table 8 below. According to the table, C07D is the most frequently appearing code. This means that the patents of the division are mostly about "new compounds or new compound's activity" which are clearly different from those of Division A's.

Figure 4 shows the network of co-classifications appearing in the patents of Division B, and Fig. 5 presents the visual illustration of the network's betweenness centrality. A61K is in the center of the whole network, in both Figs. 4 and 5. Although C07D shows highest number in terms of frequency, A61K seems to be the central field of technologies in Division B. Thus A61K is considered as the dominant IPC of Division B.

Table 6 Recipients of technology transfer from Division A (2004–2013)

Co-classification	No. of firms	Names
B01J and C07C	11	SK Energy, Hyundai Engineering, PNE, Kumho Petro-Chemicals, Hyundai Heavy Industries, SK Chemical, Samsung Petro-Chemical, KCI, Yeocheon NCC, Buheung Industries, Aekyung Petrochemical
B01J and C01B	5	E&G Tech, Hanchang Industries, Hyundai Heavy Industries, Buheung Industries, K Energy
B01J and C10G	3	SK Energy, Hyundai Engineering, SK Innovation
B01J and C02F	2	Febiane.com, Yuseong Tech
B01J and C01G	1	E&G Tech
B01J and B01D	1	Unknown
B01J and B82B	1	Unknown

Table 7 Actual Recipients that can be found in the Potential Users List

Co-classification	No. of Companies	Names of Recipients
B01J and C07C	6 (out of 38)	SK Energy, Kumho Petrochemicals, Hyundai Heavy Industries, SK Chemical, KCI, Aekyung Petrochemical
B01J and C01B	1 (out of 102)	Hyundai Heavy Industries
B01J and C10G	0	–
B01J and C02F	0	–
B01J and C01G	0	–
B01J and B01D	0	–
B01J and B82B	0	–

Table 8 Frequency of IPC

IPC	Frequency	IPC	Frequency
C07D	42	A01N	2
A61K	33	C01B	1
A61P	24	C08G	1
C07C	4	A61L	1
A23L	2	B82Y	1
B01J	1		

Sub-IPCs of Division B's Patents

A61K was identified as the dominant IPC, and we attempted to find sub-IPCs of the technology field. All IPCs that co-occur with B01J in the patents by the Division B were collected, and the closeness of the IPCs were measured as in the Table 9. The closeness measures are distributed over a number of sub-IPCs including A61P, B82Y, C07D, C08G, and C07C. Considering these IPCs, the technology fields of the Division B are mostly about developing or improving compounds that are used for medical, dental, and/or therapeutic purposes (Table 10).

Forward citation analysis

We searched for the Korean patents which citing the patents with co-classification of A61K and sub-IPCs, and collected the names of the applicants of the citing patents. Figure 6 illustrates which co-classifications are linked with (or cited by) which applicants. The Table 11 shows co-classifications in terms of degree centralities. In the table, the degree centrality of A61K & A23L is the highest at 0.145455, and it means that the technologies in the co-classifications are highly likely to be transferred to technology users. Other than A61K & A23L, the centralities of A61K & C12N and A61K and C07K are generally higher than those of others.

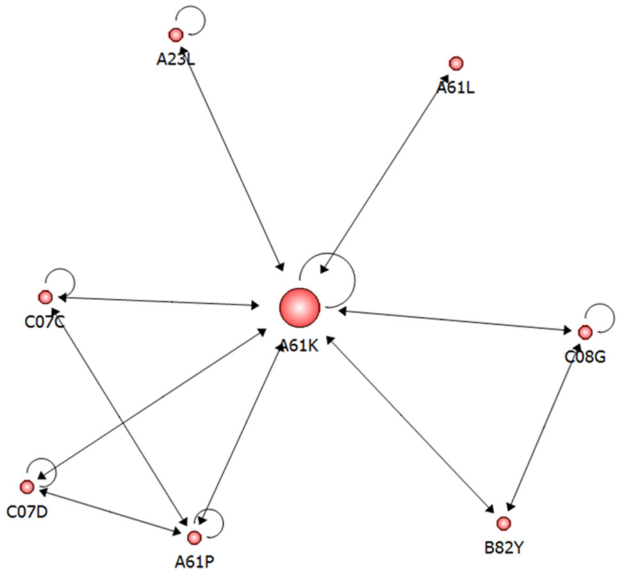

Fig. 4 Co-classification network of patents by the Division B

Fig. 5 Betweenness centrality of the network

Table 9 Closeness from the dominant IPC

IPC	Closeness
A61K	1
A61P	0.636364
B82Y	0.583333
C07D	0.583333
C08G	0.583333
C07C	0.583333
C01G	0.571429
A61L	0.538462
A23L	0.538462

Table 10 Descriptions of each IPC

A61K	Preparation for medical, dental, or toilet purpose
A61P	Specific theraputic activity of chemical compounds or medicinal preparations
C07C	Acyclic or carbocyclic compounds
B82Y	Nano technology
C07D	Heterocyclic compounds
C08G	Macromoecular compounds obtained otherwise…
C07C	Acyclic or carbocycle compounds

Potential users

Table 12 shows the names of organizations that were found in the forward citation analysis, and the table displays only 5 selected co-classifications for the purpose of presentation. Total 68 firms can be found from the table, and the number of firms for A61K & A23L is highest with 28 firms.

Verification

Table 13 shows actual recipients of Division B's patents for the period of 2004–2013. There are 2 companies in A61K & A23L, 10 companies in A61K & C07D, 1 in A61K & A61L, 2 in A61K & C07C, and 2 in A61K and C08G. The names in the Table 12 do not appear in the Table 13. It means that the potential users of technology identified by patent citation analysis do not match with actual recipients of technology.

Discussion

Among the results above, Division A's case partially support the idea that forward citation analysis can be used for identifying potential users of technology and may help technology transfer of public research institutes. For the co-classification of B01J and C07C, total 38 companies were found as potential users, and 6 among them were proved to be actual recipients of patents in the field. It can be seen a successful case of using the method for technology transfer. However, actual recipients could hardly be found in other co-classifications. Moreover, Division B's case does not support our idea.

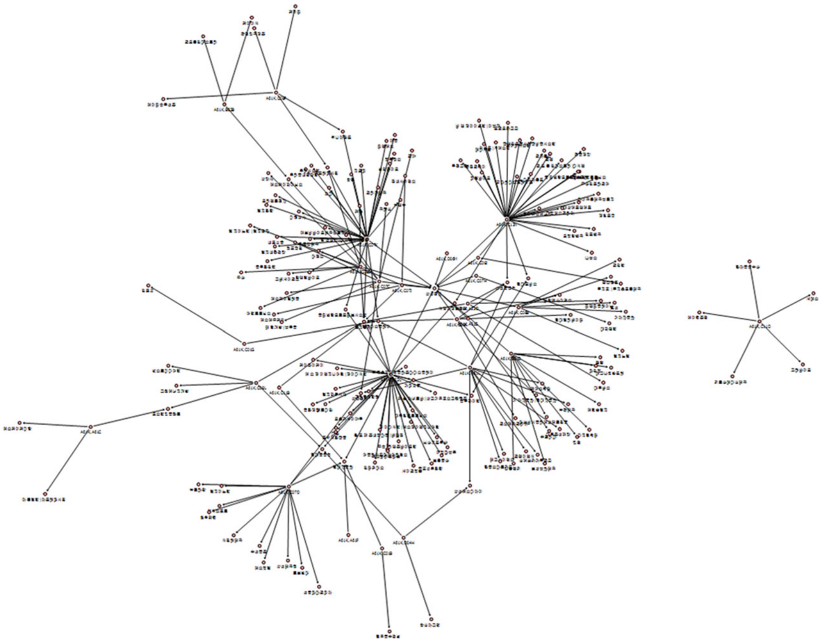

Fig. 6 2-mode network of cited co-classes and citing applicants

Table 11 Degree centrality

Co-classification	Degree Centrality
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B01J & B01D	0.192793
B01J & C01G	0.111712
B01J & C02F	0.082883
B01J & C07C	0.077477
B01J & B82B	0.064865
B01J & C10G	0.045045
B01J & H01L	0.041441
B01J & F01N	0.037838
B01J & H01M	0.037838

Table 12 List of organizations citing the patents in the co-class (potential users)

Co-classification	No. of firms	Names
A61K & A23L	28	Gapi Food, Boeun Corporation, Keunhwa Pharmaceutical, etc.
A61K & C07D	12	Samsung Electric, Samsung Techwin, Hyundai Heavy Industries, etc.
A61K & A61L	10	Bugwang Tech, DSME, Samsung SDI, LG Display etc.
A61K & C07C	11	Samsung Electric, SK Telecom, SK Hynix etc.
A61K & C08G	7	Doosan, LG Innotek etc.

Table 13 Recipients of technology transfer from Division A (2004–2013)

Co-class	Organizations that citing the co-class patent
A61K & A23L	Oscotech, Biromed
A61K & C07D	Crystal Genomics, Yu-Yu, Oscotech, ChemOn, Kainosmedicine, LG Life Science, Hanlim Pharm, Shinpoong Pharm, Donghwa Pharm, Arimed
A61K & A61L	Korea United Pharm
A61K & C07C	Donghwa Pharm, Kukje Pharm
A61K & C08G	Korea United Pharm, Heung-woo

We suspect that there are a number of reasons for this result. Firstly, the characteristics of technologies may be a factor that should be considered. Some fields of technologies are mature, so the progress of technology may be incremental, cumulative, and sometimes predictable. In this case, patent citation in the past can be a good indicator for technology needs (or demand) in the future, and therefore can be used for identifying potential users of technology. Contrarily, some technology fields are characterized by rapid progress, radical changes, a wide variety of technological options, and low predictability. In this case, we suppose technological needs or demand at present or in the future may be different from the past, and it makes forecasting technological needs difficult. This may be the reason why there are a few supporting evidences in the cases of Division A (chemical process), whilst there is no such supporting evidences for Division B (new drugs).

Secondly, we suspect that there may be some effects from company size. As we can see in the Table 6, majority of success cases are very large companies. Large companies may have a huge stock of patents, and also have a wide variety of technological needs. Then, large companies may frequently appear in any kind of patent analysis just because they are large.

Conclusion

The purpose of this study was to examine whether potential users of technology can be identified by patent citation analysis. Patent citation is basically past information, but it may be used as indicator for present or (near) future technology transfer when considering path dependent nature of technology. There has been a study that supported this view. However that approach was not easy to implement in the context of large organizations because it was based on keyword search for each patent. Therefore, we attempted to use IPC instead of keywords. By applying co-classification analysis, we identified some representative technology fields of an organization (which were expressed by dominant and sub-IPCs). Then we explored applicants of patents that cited the patents in the dominant IPC and sub-classes. Our view was that the organizations found in this procedure can be understood as potential users of technology.

To verify our view, we examined the patents and technology transfer cases of K Research Institute's Division A and B. The Division A concentrates on processes, technological life-cycle may be longer and technological environments can be more stable than others. In the case of Division B, it focuses on new drugs, so its technologies may be mostly in the early stage in a technological life-cycle. The results of the analysis supported only the case of the Division A. Based on the result, we suppose that patent citation analysis may be useful for identifying potential users of technology under a stable technological environment where the technological progress is incremental, cumulative, and sometimes predictable, but may not be so under a turbulent condition where technological progress is characterized by radical changes, a wide variety of technological options, and low predictability.

Additionally, we found that there may be firm size effect. Due to the large and diverse portfolio of patents, large firms may be more frequently appear as potential users of technology than smaller firms. We suggest that future research must deal with some methodological issues to overcome this problem.

There are some limitations of this research. Firstly, as our data come from a single research institute, the findings of this research cannot immediately be applied in real world. We suggest that there should be further research utilizing large scale data before generalizing the result of this research. Secondly, this research could have been better if detailed patent analysis were provided. The relationship between patent characteristics (such as age, legal status, and patent family size) and established technology transfer deals could have provided fuller understanding of the topic of this research. Because the data set used for this research was not drawn from a public database but prepared and provided by the K Research Institute for a limited scope of research, it was not possible to request further information. Lastly, there is a comment that actual customers of the research institute could have been analyzed. We agree that the analysis may make our research richer. However, we decided to leave the task for future research because we think analyzing customers of technology is large enough to be another independent topic.

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