Review of Recent Development in Empirical Literature on Technological Standard

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1. Introduction

International standards refer to the standards set organizations that produce standards are typically known as Standard Setting Organizations (SSOs) or Standard Developing Organizations (SDOs). While there are multiple ways to categorize these institutions, three categories are often utilized, i.e., (1) formally recognized standards bodies; (2) quasi-formal standards bodies and (3) standardization consortia. Whatever the category, it is usually stakeholders that work together on a voluntary basis to produce standard (EU, 2014).

International standards have many classifications. According to regional alliances, there are European Standard (EN) and FED ((United States) Federal Standard). In high-tech industry, there are International Electrotechnical Commission (IEC), International Organization for Standardization (ISO), International Telecommunication Union (ITU), European Telecommunications Standard Institute (ETSI), The Institute of Electrical and Electronics Engineers (IEEE). There are also national standards, like American National Standards Institute (ANSI), British Standards Institute (BSI) Canadian Standards Association (CSA), French Standard (NF) German Standard (DIN), Japanese Standard (JSA), People's Republic of China Standard (GB). etc..

At present, many countries directly use international standards as their national standards. This is due to the acceleration of economic globalization. On the one hand, the development of international trade requires goods and services that not only meet the needs of quality consistency, but also guarantee trade methods, measurement, transportation, settlement, credit, environmental protection, resources and energy conservation. With the consistency of all aspects, it is necessary to develop and apply a large number of product standards, method standard, management standard and service standard that conform to international rules. Furthermore, the standard is also a trade barrier to the international market of competition among countries, if the standards are inconsistent, it will bring obstacles to international trade. Therefore, all countries in the world are actively adopting international standards. The development of standardization in the world has posed severe challenges and important opportunities[1].

There is a substantial body of literature on the economic theory and empirical analysis for technology standards. In this paper, we attempt to focus on the recent development in this area, and give a comprehensive review from point of view of empirical studies. We discuss the definitions on technology standards, and review empirical studies related to recent topics on technology standards. We also introduce our contributions for identifying the knowledge positions of essential patents based on a social network analysis framework.

The paper is organized as follows. Section 2 discusses the definitions of technology standard, essential patent, standard setting organization and consortium. Section 3 reviews recent topics about empirical studies on technology standard. In particular, we pay attention on some development in database construction for technology standard. Section 4 introduces social network analysis on technology standards. And Section 5 gives our discussions and conclusions.

2. Definitions of technology standards

2.1 Technology standard

Standard is universally or widely accepted, agreed upon, or established means of determining what something should be, including concept, norm, or principle established by agreement, authority, or custom, and used generally as an example or model to compare or measure the quality or performance of a practice or procedure. The CENELEC[2] defines a standard formally, which is "document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context".

Standards are becoming increasingly important, as they are needed to ensure interoperability between complex products and services at various points in the value chain. Standards can strongly influence technical direction, activities and search heuristics, and thus influence technological change. In many complex product industries fields, standardization is the primary method of achieving alignment between actors (Bekkers and Marinilli, 2012). Standards also have economic effects. Practically every industry operates on the basis of technology standards, some are so mundane and pervasive that we tend not to notice them (Spulber, 2016).

For example, we can plug electric appliance into any socket in our country, or insert the USB

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1 See a review of empirical literature for international standard and trade in Swann (2010).

2 The European Committee for Electrotechnical Standardization. See http://www.cencenelec.eu/standards/DefEN/Pages/default.aspx

into any computer interface, without adjustment. This is the significance of the underlying standard, and the economic effects of technology standards extend far beyond a few high-profile legal cases in high-tech.

2.2 Essential patents

Most standard development organizations have adopted policies requiring that participants either disclose and/or license patents that are essential to the implementation of the standards (Contreras (2017)). These standard essential patents (SEPs) are indispensible in order to manufacture a product or offer a service based on the standards (Bekkers et al., 2011). Accordingly, a key element for standard development organizations' disclosure and licensing polices is how patents (or patent claims) are classified as "essential" to a standard, and what essentiality entails in practice.

Different standard development organization may define essentiality differently. Bekkers and Updegrove (2012) identify different features of standard development organization essentiality definitions that varied considerably over the ten standard setting organizations. Here we pay attention on several main features of them, and summarize those in Table 1.

Essential claims versus essential patents: Patents often contain a number of different claims, some of which may cover technology included in a standard, and others of which may not. In essential claim infringement cases, the litigants will often argue whether a given claim is, or is not, essential. In the latter case, the non-essential claims should not be licensed on fair, reasonable and non-discriminatory (FRAND) conditions. According to Bekkers and Updegrove (2012), nine of the ten standard development organizations' policies have IPR policies that refer to essential claims, as compared to "essential patents".

Table 1 Definition of essentiality at the twelve studied SSOs and Consortiums

	ITU/ISO/IEC	IEEE	ETSI	ANSI	IETF	OASIS	VITA	W3C	HDMI	NFC
Characterization	SSO	Consortium	SSO	SSO	Consortium	Consortium	Consortium	Consortium	Consortium	Consortium
Size	Large	Large	Large	Large	Large	Medium	Medium	Large	Small	Medium
Geographical focus	Worldwide	Worldwide	European /worldwide	Worldwide	Worldwide	Worldwide	Worldwide	Worldwide	Worldwide	Worldwide
Excludes commercial essentiality	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Excludes non-essential claims	Yes	Yes	No/Yes(1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Defines timing of essentiality test	No	Yes	Yes	No	No	Yes	No	Yes	No	No

Note: (1) ETSI does not explicitly distinguish between individual claims, but the commitments only apply to patents to the extent that they end up being essential. As such, actual licensing commitments are restricted to essential claims. Nevertheless, the essentiality definition is about patents as such, not claims

Source: Bekkers and Updegrove (2013)

Commercial essential versus technical essential: According to Contreras (2017), one major divide among standard development organizations' patent policies is whether they define an "essential" patent claim as covering a technical or engineering matter, which must be included in a product implementing a standard or whether that patented technology is the only commercially feasible way that the standard can be implemented in lower manufacturing cost, higher efficiency, more reliability, etc.. The former is called as "technical essential", while the latter is related to "commercial essential". In Bekkers and Updegrove (2012), eight of the ten standard development organizations' policies are limited to technical essentiality.

Timing and essential: One other important policy for standard development organizations is relating to whether a particular patent claim may be essential to a standard is the point in time at which this determination is made. Contreras (2017) pointed out that, the timing of this determination often triggers a patent-holder's obligation to disclose patents to a standard development organization and its participants, and will decide whether or not a patent must be licensed on terms specified by the standard development organizations with FRAND or royalty-free. Some standard development organizations specify that the essentiality determination should be made when a standard is approved or published, or earlier, such as when a technical contribution is submitted for consideration as part of a standard. In the estimated sample by Bekkers and Updegrove (2012), only four standard development organizations explicitly define such a point in time for the essentiality test.

2.3 Standard Setting Organization (SSO)

Generally, standards are set within Standard-Setting Organization (SSO). The SSO is an organization whose primary activities are developing, coordinating, promulgating, revising, amending, reissuing, interpreting, or otherwise producing technical standards that are intended to address the needs of a group of affected adopters. It can be both purely private or involve varying degrees of government oversight, or within trade associations which are private in nature.

SSOs affect efficiency throughout the economy, with more than one thousand organizations developing hundreds of thousands of technology standards (Spulber, 2016)[3]. SSOs involve many standard and participating members all over the world, for example, the ISO/IEC JTC 1 (an

[3] For a list of standards, see https://www.consortiuminfo.org/links/#.WxXiUYjFKUk. The list includes categorized links and overviews of 1068 organizations, and more are added as they are announced.

acronym for "Joint Technical Committee 1"), which has 3160 published standards, 510 standards under development, and 32 participating members, such as United States (secretariat), Australia, Canada, Finland, France, etc.[4]. It was formed by global standards organizations ISO and IEC to develop worldwide Information and Communication Technology (ICT) standards for business and consumer applications. Additionally, JTC 1 provides the standards approval environment for integrating diverse and complex ICT technologies. These standards rely upon the core infrastructure technologies developed by JTC 1 centers of expertise complemented by specifications developed in other organizations[5]. Thus it can be seen that SSOs provide vertical coordination among suppliers, producers and distributors, and SSOs are important for coordination of R&D, entrepreneurship, and product innovation in many industries (Spulber, 2016).

According to Braveman (2013), SSOs have many potential benefits, whose collaborative work can advance technology, promote health and safety, and enhance quality and efficiency. From an antitrust perspective, by facilitating comparability and interoperability, SSOs can lessen barriers to entry, increase competition, reduce costs, and thus serve consumer welfare. The literature in the economics focused on the institution of SSOs has largely focused on one role: that of a forum where competitors can resolve conflicts. According to Farrell and Saloner (1988), the SSO is a place where the two parties can negotiate, but has no institutional features (e.g., rules governing decision-making or requiring concessions from sponsors).

However, Braveman (2013) also point out that SSOs also have a dark side which includes: fostering anti-competitive agreements between competitors, allowing patent holdup by standard-essential patent (SEP) owners. Such standard-essential patents or other IP potentially allow their owners to extract supra-competitive returns, and possibly limit access to essential components, which would tend to reduce investment by other firms. Some SSOs also have been accused of serving as a vehicle by which some corporate members use leadership positions within the SSO to promote their own interests and harm competitors.

To avoid patent holdup problem, many SSOs adopted an intellectual property policy that requires participants in the standard's development to: disclose any SEPs during the standard's development, this can entail revelation of trade secrets and patents that may be subject to circumvention, by inventing around, or investment in complementary patents that can limit the innovators ability to earn a return on its investment. The SSOs also require patent holders

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[4] See https://www.iso.org/committee/45020.html.

[5] See https://www.iso.org/isoiec-jtc-1.html.

license any SEPs on fair, reasonable, and non-discriminatory (FRAND) terms, and also open the standard-setting process to all willing participants.

2.4 Consortium

As discussed above, standards have been traditionally defined cooperatively by governments or industry actors within formal SSOs. However, these formal SSOs are often perceived to be slow and bureaucratic, particularly when intellectual property rights have become part of the negotiation. e.g.: 3G wireless telecom standard studied here is associated with around 16,000 essential patent disclosures, and its development took most of a decade (Delcamp and Leiponen, 2012). Statistically, the speed of international standard setting of ISO and IEC is 7.5 years in 1990s. Farrell (1996) and Simcoe (2003) depict the standard-setting process as a "war of attrition" between multiple parties, the highest quality project ends up being selected. The time until this selection is seen as "delay", will be a function of the presence of vested interests.

To accelerate the process, sub-groups of firms may create less formal upstream alliances or consortia. These types of collaborative organizations offer opportunities to discuss, promote certain technologies, or they can be used to actually develop new technical specifications that will subsequently be submitted to formal SSOs for official approval (DeLacey et al. 2006). The European Committee for Standardization (Comité Européen de Normalisation or CEN) maintains a list of over 200 important international multi-vendor ICT consortia and admits that "Much of the key standardization activity in ICT is carried out by industry consortia rather than in formal standards organizations such as CEN and ISO" (CEN, 2012). In the estimated sample by Bekkers and Updegrove (2012) shown in table 1, seven of the ten standard development organizations are consortia, while only ITU/ISO/IEC, ETSI and ANSI are formal SSOs.

3. Some recent topics about empirical studies on technology standard

3.1 Roles and effects of Consortium

According to Delcamp and Leiponen (2012), monopolization of key technologies underpinning a widely used standard is likely to lead to excessive royalties and potential holdup that can slow down technology adoption and reduce social welfare. Consortia primarily is a mean to share and reduce R&D expenses, enable scale economies and reduce effort duplication among participants. Firms' incentives to collaborate in these consortiums are mutual exchange of information, access to complementary R&D, learning, influencing, and advertising. Especially small firms often join the working groups in order to learn from their competitors (Baron and Pohlmann, 2013). What's more, participation in standardization consortia may offer a venue for firms to promote their technologies and become central and powerful players in an innovation network and increases a firm's power to influence standard setting. On the other hand, due to that R&D investments create knowledge spillovers, spillovers are positive externalities that enhance the social benefits of R&D investments. Consortia may enable the internalization of these spillovers (Delcamp and Leiponen, 2012).

However, participation in standardization consortia may also have demerits. Private consortia tend to be closed and undemocratic. Firms have to support expenses such as membership fees, and travel, meeting, and human resource costs, and multiple levels of membership differentiated by a steep fee structure, whereby it can be prohibitively expensive for smaller firms to participate in the "sponsor" levels, whereas members on lower levels are likely to be excluded from committee chairpersonships, formal votes, or rights to submit technical appeals. What's more, it can induce the risks of technology leakage and imitation: internal research groups just to absorb knowledge from consortium work, secrecy is thus no longer an effective protection method and member firms may need to follow alternative appropriation strategies (Delcamp and Leiponen, 2012).

Some consortia substitute for more formal SSOs and issue their own standards, but most of them actually accompany formal standardization. Consortia is not a mean for members to contractualize R&D. However, they increase the propensity of their members to build upon each other's technology (Delcamp and Leiponen, 2012), thereby enhancing R&D coordination while improving their chances to influence the standard setting process (Leiponen, 2008) and to obtain essential patents (Pohlmann and Blind, 2012). The precise role of consortia in standard development differs substantially from standard to standard. For instance upstream consortia are active in the development of technical specifications to be submitted as proposals to the working groups, while downstream consortia deal with the promotion, maintenance or enforcement of existing standards. Baron and Pohlmann (2013) find that among the firms contributing to a standard, technological specialists are less likely to be member of a consortium. Firms specializing on the same technological components of the standard are significantly more likely to jointly be members of the same consortium, and companies are more likely to be members of the same consortium with companies specializing in R&D that is substitutable rather than complementary to their own patent portfolio. In spite of this heterogeneity, all standards consortia have in common that they consist in subsets of companies participating in a more inclusive formal standard development process, and that their objective is to coordinate their members' contribution to this shared technological standard (Baron and Pohlmann, 2013).

3.2 Strategic behavior in SEPs claim

Some recent literature focused on the values or knowledge positions of the SEPs. Baron and Pohlmann (2015) argued that, many patented inventions are made in the process of standard development (e.g. address a specific need or problem in a standardized technology), but not included in the standard. This is because many different firms make contributions to standards under development, and contributions are subject to votes by SSO members. In their recent study, Bekkers and Martinelli (2012) indicated that claims of essentiality are the results of strategic behavior of the patent's owner instead of the actual technical relevance. A strategically operating patent owner might try to get deeply involved in the drafting of the standard and use opportunities to suggest technologies that it owns patents on, if other participants have a similar agenda and incentives for such practice, it will result in increase of their own portfolio of essential patents.

As most formal standards bodies have adopted a FRAND policy, members are obliged to notify any essential patent they hold, and are requested to issue a public statement that they are willing to license for royalty-free or royalty-bearing under the FRAND conditions. However, this procedure may create some degree of uncertainty about using the lists of essential patents as indicator for knowledge position. First, companies are allowed to submit "blanket claims", stating that they will license essential patents on FRAND conditions. Such blanked claims do not reveal individual patents, but help their owners possess large portfolios of essential patents even if the owners don't own any essential patents at all. Inversely, there is some degree of "over-claiming", where firms declaring patents to be essential while they are not in fact, for the purpose of licensing their patents (Bekkers and Martinelli, 2012). And this may arise from few legal or regulatory penalties associated with declaring too many patents as essential versus severe penalties for under-declaring (Contreras, 2017).

3.3 Technology standard and knowledge spillovers

It is well understood that the non-rival nature of knowledge as a productive asset creates the possibility of "knowledge spillovers". Economists have been attempting to quantify the extent and impact of knowledge spillovers. One line of research of this type has utilized patent citations to identify a "paper trail" that may be associated with knowledge flows between firms (Jaffe and Trajtenberg, 2000). Patent citations presumably convey information or knowledge flows between innovations or patent holders. The number of citations a patent has can also been seen to be linked to the market value of the company owning the patent and the value of the technology (Hall, et al. 2005). Leiponen (2008) studied a number of consortia contributing to 3GPP. She shows empirically that connections with peers in related consortia enabled members to better influence the selection of standard components at 3GPP. Delcamp and Leiponen (2012) set up an empirical model to test whether consortium participation by a firm increases the likelihood that its patent is cited by other members of the same consortia in their patents that are declared as essential for the wireless telecommunication system UMTS. The results show that joining a consortium connected with 3GPP increases cross-citations between the members' patents. If a firm attended a relevant technical consortium, other members of the same consortium were significantly more likely to cite its earlier patents in their own current patents that eventually led to essential IP declarations. They also argue that if knowledge spillovers rather than strategic citation are primarily driving citations, then technical consortia should be more conducive to them. Baron and Meniere (2014) also observe an increase in patent output after a firm joined a consortium. What' more, in Baron and Pohlmann (2014), they predict standard setting organizations may be oriented towards two different regime--Public Good or Rent Seeking, that induce opposite effects of consortium formation on firms' R&D investment. They established a model to demonstrate the innovation output, as measured by the number of citations-weighted patent priority filings. The empirical results show that companies increase their own output of citation-weighted patents after joining a consortium. Other consortium members also increase their innovation output as a reaction to a new firm joining the consortium. Both effects are significantly weaker or even revised in the case of a Rent Seeking regime.

3.4 Some development in database construction for technology standard

As indicated by Baron and Spulber (2015), because the development and implementation of technology standards interacts with economic decisions and market transactions, it is necessary to take standards into account in empirical economic analysis. Thus, some databases are created for this purpose.

The Searle Center Database on Technology Standards and Standard Setting Organizations (SSO) is made by Baron and Spulber in 2015[6]. The Searle Center Database consists of quantifiable

[6] See http://www.law.northwestern.edu/research-faculty/searlecenter/innovationeconomics/data/technologystandards/.

characteristics of 797,711 standard documents issued by 615 different SSOs, and the database describes the rules of 36 SSOs on standard-essential patents (SEPs), openness, participation, and standard adoption procedures. In addition, the database identifies institutional membership for a sample of 191 standards organizations including SSOs and other organizations directly involved in the development of technology standards. What's more, the database includes information on various document characteristics, such as the publication date, the issuing SSO, the technological classification, the number of pages, references between documents, equivalence between documents issued by different SSOs, and withdrawal dates (if the document is inactive).

On the other hand, Bekkers et al. built Disclosed Standard Essential Patents Database (dSEP) which was previously called as the OEIDD database[7]. The dSEP database provides a full overview of all disclosed IPR at setting organizations world-wide. Based on the archives of thirteen major SSOs as of March 2011, the disclosure data is cleaned, harmonized, and all disclosed the United States Patent and Trademark Office (USPTO) or the European Patent Office (EPO) patents or patent applications are matched against patent identities in the PATSTAT database[8]. Overall, the database contains 45,349 'disclosures' (disclosed patents, patent applications or blankets), from 938 different firms or organizations, with 13,402 USPTO or EPO patents or patent applications identified in PATSTAT (with 6900 unique USPTO or EPO patents or patent applications), belonging to 4816 different INPADOC patent families and 5340 different DOCDB patent families[9].

In summary, the two database introduced above cover the common aspect, they both pay attention the big famous SSO like CEN (European Standard Committee), IEC (International Eletrotechnical Commission), ISO (International Organization for Standardization) and JTC1 (introduced last chapter). And they both provide the information about which companies are involved in each SSO, together with year information and the patent office. As for the quantity of information, of course the former is bigger and we can easily use the statistical analysis software to analyze the competition or cooperation of firms in each SSO. In addition, more topics can be found, like consortium and patent citation (introduced in the following chapter). However, the

7 See http://ssopatents.org/.

8 EPO Worldwide Patent Statistical Database. See the following website for more details, https://www.epo.org/searching-for-patents/business/patstat.html#tab-1.

9 INPADOC are Legal status data that relates to information on the events during the lifetime of a patent application and DOCDB data is the backbone of many commercial products and services. It includes bibliographic data from over 90 countries worldwide. See the following website for more details. https://www.epo.org/searching-for-patents/data/bulk-data-sets.html.

later database provides us with more detailed information like unique application ID for each patent, which can be used to merge with larger database like PATSTAT for further information. And how to better combine the two databases will also be a research project for the users of the databases.

4. Social network analysis on technology standards

The social network analysis is recently becoming a useful analysis tool along with statistics. Network-based analysis allow not only for investigation of patent networks but also for the aggregation of these into networks of firms. Network-based techniques such as the "main-path analysis" were pioneered by Hummon and Doreian (1989). In the recent past, number of papers employed this approach for mapping technological trajectories (Mina et al., 2007, Fontana et al., 2009 and Barbera-Tomas et al., 2010). Specific algorithms can be used to identify the "centrality position", role of brokerage and "main flow of knowledge" within the technology standards' network. Especially the main flow of knowledge is a set of connected patents or SEPs held by members of the SSOs or consortiums linking the largest number of patents of the network and therefore cumulating the largest amount of knowledge flowing through patent citations. This path represents therefore a local and cumulative chain of innovations consistent with the definition of technological trajectory.

Based on a social network analysis on patent citation network related to the 3G W-CDMA standard, Bekkers and Martinelli (2012) proposed an alternative indicator, i.e., "main-path" to investigate the knowledge position of the SEPs in the standard network, where they assumed that main-path is an accurate description of the importance of knowledge position in the patent citation relation, and that most of the patents on this main-path should be claimed essential to the standard. They implement an empirical analysis to test whether network-based methodologies are more suitable for determining firm's knowledge position of the claimed SEPs than traditional analysis.

They begin with a patent citation network of the claimed SEPs, where nodes correspond to the SEPs and the links are citations between these patents. Next, each of the links is given a SPLC value[10]. Finally, one or more trajectories will be found with the links that have the highest SPLC value. The trajectory has the highest cumulative value of all the weights of its links is

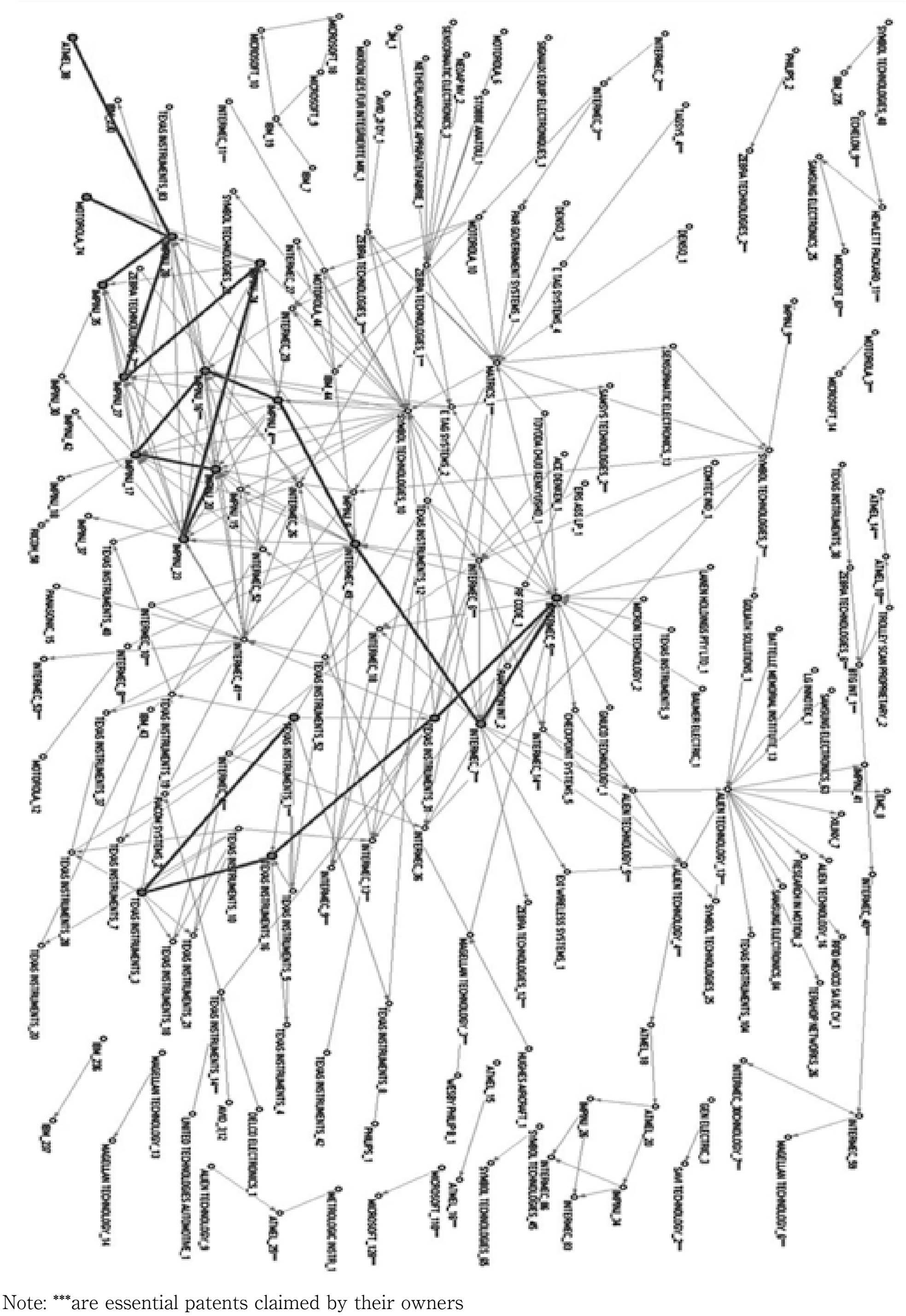
[10] SPLC weights each edge proportionally to how often a given link is present all the paths that can be constructed for many start point (i.e. patents that do not cite any other patents) to any endpoints (i.e. patents that does not receive any citations).

called the “top main path”. This path is considered to cumulate the most important knowledge in the network and represent the chain of most important inventions (Dosi, 1982). However, they observe only approximately 33% of the patents lying on the trajectory are claimed essential in their figure, and 20% in their table. Thus, Bekkers and Martinelli (2012) implied that, there is only a weak link between the knowledge position measured by the main-path in the patent citation network and whether the patent is claimed by its owner to be essential.

These results are in line with a more recent research by Jiang and Zhang (2016). In their paper, they pay attention on essential patents declared by member firms in JTC1, a SSO discussed in Section 2. Their sample includes 1149 essential patents declared by 63 member firms during the period of 1995-2010. They build a dataset for the citation relationships between the patents, which involves more than 15000 pairs of citations between the essential patents and between the essential patents and other patents held by the member firms. As shown in Figure 1, their findings illustrate a selected citation network in which the values (or weight) of the SPLC are larger than 0.004. The network consists of 180 patents and out of them 41 patents with “***” are the SEPs, which are shown in a solid line. The main path comprises 5 essential patents and 13 other patents that are not claimed by the SSO member firms. What’ more, they show in their tables, although the average values of the SPLC for the SEPs are larger than those for no claimed patents, compared with the latter, the former does not overwhelmingly contribute to the main-path. This finding in the JTC1 is consistent with Bekkers and Martinelli (2012).

Given the success of this approach in understanding the main flow and the development of patented knowledge, it might be promising for providing insight into the knowledge position of the firms that own those patents. As indicated in Bekkers and Martinelli (2012), however, the granularity of this method might restrict it usability in this context: even if the full network comprises thousands or even ten thousands of patents, the identified main path of knowledge often comprises few dozen of patents or even less. This “over selective” problem may result in serious limitations, and lead to misunderstanding the knowledge positions of the SEPs.

Figure 1. Main Path in Selected Citation Network



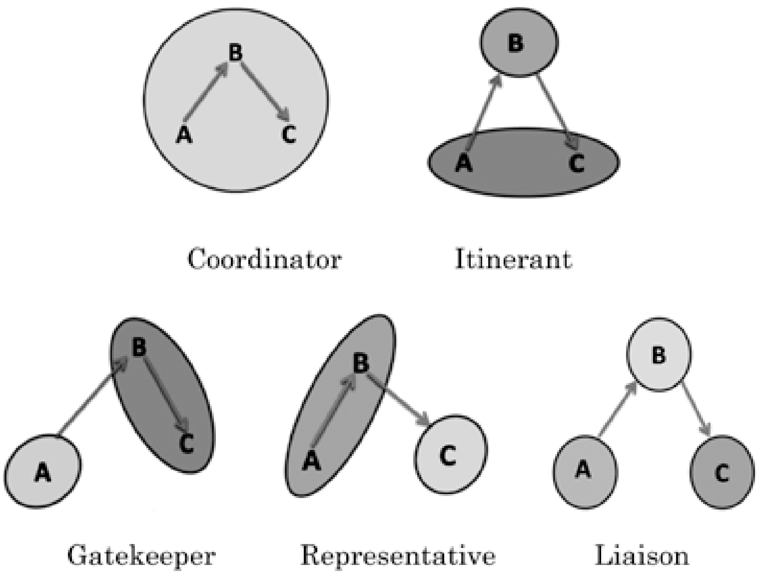
Note: ***are essential patents claimed by their owners
Source: Jiang and Zhang (2016)

On the other hand, as development of the social network analysis techniques, Gould and Fernandez (1989) proposed a knowledge broker typology framework. The advantage of the broker position in a network is that the participants who are positioned as information brokers between groups with different information backgrounds benefit from information flows, and have a positive influence on their quantitative and qualitative output, and even can induce competition or conflict between neighbors who are not linked directly. Thus, the approach to brokerage and affiliations may help us to understand more the roles of patents that dominate a transactional or exchange of knowledge network. The roles of the actor in the network could be quite divergent, and categorized such as “itinerant brokers”, “representative”, “gatekeeper”, and “liaison”.

Figure 2 depicts the categories, where the triad in which actor B mediates transactions between actor A and actor C can display five different patterns of group affiliations. In the triad of “coordinator”, all actors including the broker B and the source of knowledge are in the same cluster. In the “itinerant” framework, the broker B mediates between actor A and C that are in the same cluster, but the broker B is not part of this cluster. “Representative” role is given if a cluster delegates the brokering role of external knowledge to someone in the other cluster. “Gatekeeper” screens external knowledge to distribute it within its own cluster. “Liaison” is when the knowledge is brokered across different clusters, broker B is not a member of either cluster.

According to Jiang and Zhang (2016), in their sample 81% of the SEPs play the roles of “itinerant” and “liaison” respectively, while those for the patents not claimed are less than 2%. Their finding suggest there is a strong relationship between the broker roles and the SEPs such as “itinerant” and “liaison”, which means the patents that serve as itinerant and liaison may be more likely to be claimed as the SEPs.

Figure 2 Image of brokerage roles



5. Conclusions and Discussions

In this paper, we focused on the recent development in technology standard, and gave a comprehensive review from point of view of empirical studies. We discussed the definitions on technology standards, and surveyed empirical studies related to recent topics on technology standards. We also introduced our contributions for identifying the knowledge positions of essential patents based on a social network analysis framework.

Japan has attached great importance to standardization. The current standardization system in Japan has been contributing greatly to the development of the manufacturing industry and the improvement of the living of the people since the establishment after the war. However, there are also problems during the process of standardization, for example, the number of international standard led by Japan is limited, and thus it is difficult to meet the need to participate in international standards competition. And there is not a tendency that individual companies are formulating rules to expand and acquire markets compared to the United States and European countries (METI, 2017).

More specifically, the Japanese market is often independent of the European and American markets, showing the phenomenon of independent evolution. The development standards of European and American countries are divided into three stages. The first step is to identify the requirements, and then spend a lot of time talking about what state can be reached with the standard. The second step is to figure out how to satisfy the condition. The third step is to consider detailed implementation techniques.

Japan, however, tends to move from the first step to the third. So while the Japanese companies in technology is undisputed, has many of the world's first, but once the European and American market enterprises to abandon the standard put forward by Japanese companies, in turn to implement other standards, can easily will edge out Japanese companies from European and American market. As a result, Japanese companies have failed to capture the international market in standardization.

Based on this situation, it is more important than ever to actively participate in international standardization and to ensure international consistency in JIS/JAS and domestic regulations[11]. Also, it is necessary for companies and the governments to be involved quickly in the rules' formation before technological marketization is realized, and propel the open innovation beyond the national border, R&D and standardization simultaneously proceed in global corporate consortium.

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[11] JIS and JAS refer to Japanese Industrial Standards and Japanese Agriculture Standard.

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