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# Empirical Analysis of License Policy for Declared Standard-essential Patents in Setting Technology Standards

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# Empirical analysis of license policy for declared standard-essential patents in setting technology standards*

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Abstract

Standard-setting organizations (SSOs) generally request that their participants commit to offering licenses ex ante to implementers on fair, reasonable, and non-discriminatory (FRAND or RAND) terms. To adjust for the RAND context, court judges adopt modified Georgia-Pacific rules to determine patent damages ex post in infringement lawsuits involving standard essential patents (SEPs). In this paper, we review the literature on intellectual property rights policy in SSOs and modified Georgia-Pacific rules from court practices and explore the determinants of licensing terms in the RAND context from both technical and legal aspects in accordance with the review. By employing a novel dataset that consists of over a thousand declared SEPs in the Internet Engineering Task Force (IETF), we find that, in general, technical and legal characteristics are significantly associated with reciprocal licensing terms, despite most of their associations with royalty-free (or royalty-bearing) terms being nonetheless trivial.

Keywords: standard-essential patent; FRAND; license contract; reciprocal clause
JEL classification: L24; O34



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## 1. INTRODUCTION

Standards have become increasingly important to firms in high-tech industries , where standard-setting organizations (SSOs) are inevitable in setting up standardization policies while managing standardization processes (Farrell & Saloner, 1985; Farrell & Simcoe, 2012; Kang, Huo, & Motohashi, 2014; Kang & Motohashi, 2015; Simcoe, 2012). Among other polices in SSOs, intellectual property rights (IPR) policy draws broad attention from SSO participants (Bekkers, Duysters, & Verspagen, 2002). Each SSO has its policy about IPR with respect to the standards proposed and established in the SSO. For example, IETF issued a series of Request for Comments (RFCs) (an updated version RFC 8179) to guide all IPR relevant issues in the scope of IETF (Bradner & Contreras, 2017).

In general, IPR policies in SSOs request participants to disclose information about their own or others' IPR, including, but not limited to, standard-essential patents (SEPs) and licensing commitments to offer these SEPs' licenses on fair, reasonable, non-discriminatory (FRAND or RAND) terms.[2] The RAND terms can help to mitigate the risk of patent holdup and royalty stacking (Lemley & Shapiro, 2007). The purpose of RAND terms is to ensure adoption of standards as wide as expected by SSOs' original mission on technology diffusion, and the extant evidences have proved that SSOs identify promising technologies and influence their subsequent adoption (Rysman & Simcoe, 2008). However, in court practices, policy- and decision-makers such as Judges need not only to carefully reconsider the RAND context beyond the technology diffusion mission that makes sure firms do not get blocked from implementing standards owing to the unavailability of licenses to SEPs, but also to ensure adequate reward to SEP owners for their contributions to standards and to implementers.

[2] "FRAND" is commonly used in European-based SSOs, while "RAND" commonly appears in U.S.-based SSOs. The two terms are acknowledged interchangeable in all circumstances.

The most critical essence of RAND principles is *reasonable*, while neither *fair* nor *non-discriminatory* is hard for decision-makers to determine or judge. Both court judges and the scholarly literature of patent law and contract are mostly concerned about how patent damages get determined and compensated *ex post*. In the present paper, instead, we focus on SEP holders' decision-making about the *declared* RAND terms in their licensing commitments *ex ante* (Layne-Farrar, Padilla, & Schmalensee, 2007).[3] Despite their distinct purposes and questions, the two research directions share a same nature that involves patent pricing or the determination of a patent's economic value. Given that licensing commitments are proactively disclosed and declared by SEP holders themselves, it is supposedly logic to contend that the RAND terms in such commitments are determined based on the holders' valuation on their SEPs. The innovation literature has shed much light on the determinants of patent value (Belderbos et al., 2014; Lanjouw & Schankerman, 2004), among which, for example, a variety of patent characteristics such as forward citations (Trajtenberg, 1990), patent scope (Lerner, 1994), and renewal (Lanjouw, Pakes, & Putnam, 1998) were found positively associated with the economic value of patents and/or firms who hold them.

Among possibly a great number of determinants from many other theoretical perspectives, we intend to examine SEP holders' decision-making on the declared RAND terms in their

[3] Because the disclosure of information on SEPs and RAND terms relies only on patent holders and other SSO participants, SEPs in our examination are actually *declared* SEPs (dSEPs). In most literature (including lawsuits) and our paper, a dSEP is not deliberately discriminated from a SEP that is genuinely essential (e.g. commercially essential, technically essential, or eventually being incorporated into a standard) since we focus on what determine the decision-making about the declared RAND terms in licensing commitments *ex ante*. Thus, dSEP and SEP are interchangeable in our paper.

licensing commitments under the guidance of a list of so-called *Georgia-Pacific* rules from court practices. Given that the *Georgia-Pacific* factors, established in U.S. and also referenced in many other countries, have widely been adopted as *de facto* rules to assist determining patent damages in court decisions, a research framework based on such rules will provide a useful and practical perspective to our understanding of RAND licensing commitments in SSOs.

The reminder of the article is organized as follows. Section 2 introduces the general licensing policy in SSOs, especially IETF. Section 3 introduces the Georgia-Pacific rules and the modifications made for the RAND context in earlier U.S. court practices, followed by the hypothesis development about the determinants of RAND terms in licensing commitments. Section 4 specifies the methodology for the empirical examination on our sample organized from the IPR information at IETF, and Section 5 presents the empirical results. Finally, we discuss the results and future directions, and conclude our contributions to the literature in Section 6.

## 2. LICENSING COMMITMENTS IN STANDARD-SETTING ORGANIZATIONS

Albeit differences across SSOs (Chiao, Lerner, & Tirole, 2007), IPR policy is generally purposed for encouraging (or sometimes even enforcing) SSO participants to timely provide adequate information for decision-makers in these SSOs to consider when conducting relevant standards. For example, in RFC 8179 issued by IETF, the general policy is written: "*In all matters relating to Intellectual Property Rights, the intent is to benefit the Internet community and the public at large, while respecting the legitimate rights of others. The disclosures required by this policy are intended to help IETF working groups define superior technical solutions with the benefit of as much information as reasonably possible about potential IPR claims relating to technologies under consideration*" (Bradner & Contreras, 2017) (page 8).

On the one hand, disclosing IPR information is rather flexible for SSO participants as such an act appears to be merely informational to SSOs. Sometimes, firms even strategically make

generic or blanket statements that do not provide detailed IPR information to specify SEPs or licensing terms for a variety of reasons (Lerner, Tabakovic, & Tirole, 2016). On the other hand, the disclosed IPR information would be of great help when encountering patent infringement suits. Court judges would rely much on RAND commitments to determine both the existence of patent infringements and the exact damages (i.e. reasonable royalties) for infringers to compensate. Once a patent holder makes a RAND commitment, it gives up the right that it otherwise would have had to refuse to license its SEP to others keeping for its own exclusive use, and the right to discriminate among licensees (though defensive clauses on reciprocal licensing may still "discriminate" among licensees to a certain extent). Nevertheless, it is worth to notice that RAND commitments are made to commit a future act to offer licenses to implementers on declared RAND terms. In other words, most of time, actual negotiation remains needed to direct at licensing a patent subject to the RAND commitments; otherwise, SEP owners may assert their rights to claim injunctions or patent damages from implementers.

Specifically, IETF explicitly provides the following six SEP declaration options for SEP owners to select. They are: *a) no license required for implementers; b) royalty-free, reasonable and non-discriminatory license to all implementers; c) reasonable and non-discriminatory license to all implementers with possible royalty/fee; d) licensing declaration to be provided later (implies a willingness to commit to the provisions of a), b), or c) above to all implementers; otherwise, the next option 'unwilling to commit to the provisions of a), b), or c) above'. - must be selected); e) unwilling to commit to the provisions of a), b), or c) above; and f) see text below for licensing declaration*. In most SEP declarations, patent owners provide additional licensing information that detail the specific terms, including an explicit statement of RAND term and whether it is royalty-free or royalty-bearing. Importantly, the licensing information in many SEP declarations also includes a "defensive suspension" clause that specifies the necessary condition of the RAND term, allowing a SEP licensor to terminate (or alter) a license

upon the occurrence of a certain event, such as being excluded from *reciprocal* licensing and being sued for infringement by a licensee. Despite that most SSOs appear to limit reciprocal licensing obligations to only the particular standard (or standards) at issue, some reciprocal licensing clauses are not properly made within the scope of the particular standard(s), which could allow an SEP owner for a *de facto* license to a licensee's entire portfolio. Nevertheless, upon a specific lawsuit for patent infringement or a decision on the incorporation of the SEP into a standard, decision-makers such as court judges and SSO directors would not rely fully on such unlimited-scope clauses but rather evaluate them *reasonably*. We classify the IETF's RAND terms and give license term examples in Table 1. The last row shows terms with defensive suspension clauses.

(TABLE 1 HERE)

There are at least two reasons for us to believe patent value is the most primary driver of SEPs' declared licensing terms. First, SSOs such as IETF usually request *timely* IPR disclosure from participating members because "*working groups need to have as much information as they can while they are evaluating alternative solutions*" (Bradner & Contreras, 2017) (page 11). Second, in the U.S. court suits, Judges believe that *"RAND royalties should be interpreted to limit the patent holder to a reasonable royalty on the economic value of the patented technology itself, apart from the value associated with the patent's incorporation into an industry standard"* (e.g. *Microsoft v. Motorola*, 2012). Thus, we could, to a certain extent, assume that firms determining and declaring SEPs' terms primarily based on their own perception and evaluation on the value of the SEPs that is inherent to technologies at issue, rather than on other strategic concerns such as an award from network effect that would be led by the SEPs' incorporation into standards. Further, it is likely that a SEP holder prefers to include a defensive suspension clause in the RAND term when it believes that this SEP has a

high value because such a clause appears to leave it an option to reclaim the IPR upon certain conditions such as occurrence of non-reciprocal licensing from any implementer.

## 3. FACTORS AFFECTING SEP VALUE

To determine the economic value of SEPs, patent owners may resort to extant methodologies from common practices, especially those from court practices in IPR-relevant lawsuits given that valuing patents is common in patent infringement cases. The U.S. courts often adopt Georgia-Pacific rules in the royalty determination of patent infringement. The rules originate from a seminal lawsuit *Georgia-Pacific v. United States Plywood* (1970) in the Southern District of New York.

Faced with the unique context of RAND licensing commitment in SSOs, certain modifications were made to adjust for the context in an influential suit for patent infringement of *Microsoft v. Motorola* (2012). In this suit, Judge Robart proposed that it was reasonable to modify the fifteen Georgia-Pacific factors and use them in determining reasonable-royalty damages in the RAND context. To summarize, the modifications of Georgia-Pacific factors in this suit established and, probably have sofar, reached a general agreement on four understandings or rules for the other subsequent suits in the RAND context. First, a RAND royalty should be determined in consideration of promoting adoption of the standard at issue. Second, determining RAND terms should recognize that the terms should mitigate risk of patent holdup and royalty stacking. Third, RAND royalties should guarantee patent holders a reasonable award on SEPs. Fourth, RAND royalties should be limited to a reasonable return on the economic value of the patented technology itself, apart from the value associated with the patent's incorporation into a standard. In such a sense, the contribution of a patented technology (i.e. SEP) to a standard, and the contribution of the standard to an implementer's products, are basic factors in courts' determination of patent damages in the RAND context.

Consequently, we content that a most general rule of thumb for SEP holders to make specific RAND commitments in SSOs is the *de facto* economic value of the SEPs at issue. In the literature of innovation, especially studies on patent, a patent's economic value is acknowledged to be associated with its characteristics with respect to technology and IPR (Harhoff, Scherer, & Vopel, 2003; Lanjouw et al., 1998; Lanjouw & Schankerman, 1997; Lanjouw & Schankerman, 2004; Lerner, 1994; Trajtenberg, 1990). Taking together the Georgia Pacific Factors, we constitute the following hypotheses, in terms of economic value of the SEPs, and their relationship with ex-ante licensing declaration.

### 3.1. The Influence of Technology

On each patent, there are a few bibliometric indicators on technical characteristics that are acknowledged to determine the patent's technical value and in turn its economic value. Among other indicators, we focus on technical scope that refers to the breadth of technical fields a SEP covers and the extent to which the patented invention is directly related to any standard (or standards).

**Technical scope**. Patent examiners need to determine technical classification of patent applications and assign at least one proper technical classification code to each of them, albeit different classification systems such as U.S. patent classification (USPC) and international patent classification (IPC). These assigned technical classification codes of a patent application constitute a general scope of the patented technology, within which patent examiners can search for prior art to determine its patentability (e.g. novelty, non-obviousness, and usefulness). In general, a broader technical scope suggests a broader use of a patented technology that consists of components from multiple technical fields, which may also drive subsequent technical development in these fields. Therefore, a patent with a broader scope is likely to have a higher technical value, and its owner is likely to profit from it directly and thereby license it for a royalty return. Further, a broader technical scope also suggests a greater

likelihood for others patent holders' patented inventions to overlap in the same technical fields, thereby the relevance of the patented inventions from both parties arises and so does their interoperability in a standard or related standards. In this regard, implementing the standard(s) would be conditional on the IPR of SEPs from both holders, and thereby it is likely that the holders licensing these SEPs on RAND terms with reciprocal licensing clauses. Thus, we hypothesize:

*Hypothesis 1a. A SEP with a broader technical scope is likely to be licensed for royalty.*

*Hypothesis 1b. A SEP with a broader technical scope is likely to be licensed with a reciprocal licensing clause.*

### 3.2. The Influence of Legal Factors

A patent document specifies the extent to which the IPR legally protects the patented invention. Three dimensions, breadth, length, and strength, of IPR are highlighted, to which patent characteristics such as legal scope, duration, and family size are associated respectively. Legal scope refers to the breadth of IPR protection. Legal duration indicates how long the protection lasts with the patent term. Family size reflects a patent's protection in multiple countries, implying legal strength worldwide.

**Legal scope**. Despite differences patent law regimes and patenting systems across countries, patents grant owners legal rights to exclude others to making, using, selling, importing or offering for sale commercial products that implement the patented technologies. Legal scope is closely related to the probability that a patent is litigated (Lanjouw & Schankerman, 1997). There will be a greater number of potential users or implementers that would like to earn the IPR license of a patent that has a broader legal protection, because it is hard for the implementers to invent around the large-scope patent without infringement. As such, it is reasonable for the patent holder to price the patent license at a higher royalty rate than other narrowly weakly protected patents. Further, given that a patent with a broader legal

scope has a greater likelihood of being infringed by others, declaring an reciprocal licensing clause would allow the SEP owner for flexibility and value-adding to the SEP by the option. Thus, we hypothesize:

*Hypothesis 2a. A SEP with a broader legal scope is likely to be licensed for royalty.*

*Hypothesis 2b. A SEP with a broader legal scope is likely to be licensed with a reciprocal licensing clause.*

**Legal duration**. Judge Robart stated in the *Microsoft v. Motorala* (2012) suit that *"the analysis concerning Factor 7 is greatly simplified in the context of a dispute over a reasonable royalty for a RAND-committed patent because the term of the license would equate to the duration of the patent. In many circumstances, this factor will have little influence on what constitutes a reasonable royalty under the RAND commitment."* A valid patent is endowed with an exclusive IPR within a limited period. In the U.S. and most patent laws nowadays, the term of a granted utility patent is twenty years from the earliest filing date of the application.[4] The value of a patent largely depends on the time period of its IPR. If a patent expires soon, potential users of the patent are likely to wait for the expiration and use it for free without any infringement or actual negotiation process. Accordingly, the patent holder may be willing to license it at a low rate, or just for free to avoid additional costs owing to a negotiation for both parties' agreement on a reasonable royalty rate. Besides, licensing a patent with little economic value owing to short duration for free may, however, leverage the likelihood of the patent being incorporated into a standard because the IETF has a tradition that prefers "free" technologies. Further, for a similar reason, addressed earlier for legal scope, that a patent with a longer legal duration has a greater likelihood of being infringed by others, declaring a reciprocal licensing

[4] In the U.S., The twenty-year term is for utility patents filed on or after June 8, 1995.

clause would allow the SEP owner for flexibility and value-adding to the SEP by the option. Thus, we hypothesize:

*Hypothesis 3a. A SEP with a longer legal duration is likely to be licensed for royalty.*

*Hypothesis 3b. A SEP with a longer legal duration is likely to be licensed with a reciprocal licensing clause.*

### 3.3 The Influence of Juridical Coverage

**Family size**. Prior studies have found that family size of a patent is positively associated with its economic value (Harhoff et al., 2003; Lanjouw et al., 1998), because a holder of a valuable invention often seek patent protection in as many jurisdictions as possible to ensure its exclusive legal power worldwide. The rationale behind such wider power of the patent is its assignee's intention to keep wider potential market of the protected technology and/or the product. Therefore, it is likely that one who holds such a SEP decides to profit from the valuable patented technology directly, and thereby committing to offer licenses on a royalty-bearing RAND term.

In contrast, it is not necessary to cover wide juridical coverage for defensive purpose of declared SEPs for future licensing deal, since the patent in US (USPTO patent), where most of firms use cover as a juridical area is enough. The marginal benefit of patent applications for wider countries/regions is small for this purpose, while the cost of patenting substantially increases. Moreover, the defensive use of SEPs by reciprocal licensing clause is more relevant for free licensing declaration, since the licensed for royalty clause itself contains a room for ex-post licensing term freedom of declared SEP, depending on subsequent licensing negotiations with other patents. Thus, we hypothesize:

*Hypothesis 4a. A SEP with a larger family size is likely to be licensed for royalty.*

*Hypothesis 4b. A SEP with a smaller family size is likely to be licensed with a reciprocal licensing clause*

*Hypothesis 4c. Hypothesis 4b is particularly relevant when the SEP with loyalty free is declared.*

### 3.4 Relevance to technology standards

**Standard reference**. For both patent applicants and examiners, non-patent literature (NPL) is necessary in their search for prior art to fulfilling the report duty and determining a patent application's patentability. Standard is a critical source of NPL, which is particularly relevant to SEPs examined in our research context. A patent that cites an extant standard is, to a certain extent, related to a technology component in the standard. Such a patent may create a sizable revenue for its owner either from product market or technology market (Arora & Fosfuri, 2003; Gambardella, Giuri, & Luzzi, 2007; Motohashi, 2008), since the standard could facilitate implementers' adopting technology in product market. Therefore, this patent is likely to be believed valuable and be licensed on a royalty-bearing term.

However, it should be noted that a license with loyalty has negative impacts on potential diffusion of standardized technology, and a firm have incentives for free licensing to increase the size of eco-system based on the standard to maximize a profit from downstream market. Taking into consideration of standard competition, a network sponsor (with core SEPs to technology standard) may offer competitive price of its technology to increase the size of it user with complementary technologies and services (Katz and Shapiro, 1994).

Therefore, in case of license declaration with royalty fee, a marginal contribution of reciprocal clause is small, since ex-post licensing negotiation can be made by royalty condition of the SEP per se even without reciprocal clause. Or it is even detrimental from the viewpoint of eco-system enlargement. In contrast, in case of free licensing declaration, a firm with SEP relevant to the standard expects to have large downstream market, so that potential holdup risk by its competitors' patents in the market becomes greater. Therefore, the firm has more

incentive to include reciprocal clause in its SEP licensing clause declaration. Thus, we hypothesize:

*Hypothesis 5a. A SEP that references a standard is less likely to be licensed with reciprocal clause when it is licensed for royalty.*

*Hypothesis 5b. A SEP that references a standard is likely to be licensed with a reciprocal licensing clause when it is licensed for free (non royalty).*

## 4. METHODOLOGY

### 4.1. Data and Sample

***IETF IPR disclosure data.*** We use IPR disclosures made by patent owners before the end of 2017. There are three kinds of IPR disclosures: 1) generic IPR disclosures, which describes an organization's general IPR policy relating to IETF standards; 2) specific IPR disclosures, which declares a patent holders' ownership of potential IPR relating to some specific RFC standards or proposals (i.e. internet-draft) and possible license terms; 3) specific third-party IPR disclosures, which are submitted by a third party to warn potential IPR existence relating to some specific RFC standards or proposals. We only use specific IPR disclosures in this study as patents cannot be identified from Generic IPR disclosures and licensing terms cannot be identified from third-party IPR disclosures. In total, we got 2530 disclosures. However, among these disclosures, there are duplicates entries for the same information or invalid inputs such as "test". We only use the disclosures with valid IPR holder, patents numbers, and RFC/internet-draft information, which resulted in 1,901 valid disclosures.

***Matching IPR disclosure data with patent data.*** To create technical scope, legal scope and other patent level indicators, we need to match the disclosure information with patent data. The IETF does not have a standard format requirement for submitting patent numbers, thus firms may provide patent grant number, application numbers, or publication numbers in free

text format. We parsed the text and retrieved any kind of patent number, together with patent authority (i.e. country) information and tried to identify the types of these number according to the patterns and ranges. Since the patterns are country specific, and some patent indicators are only comparable within a patent authority, we limit our sample to U.S. patents only. Among 6012 patent numbers identified, 4,436 are from USPTO. A manual sampling check of the remaining 1,576 patent numbers of other authorities are mainly of the same patent family with those filed in USPTO.

We then matched the 4,436 patent numbers and publication kind (application number, serial number or grant number) to PATSTAT 2017b patent database and identified 1,005 unique patents as many patents are disclosed with different kinds of patent numbers multiple times. Thus, we are able to retrieve patent bibliometric information from PATSTAT database, including number of claims, filing date and patent family size. The data is further matched to PatentsView US patent database to retrieve disambiguated assignee information and citation information.

***Matching IPR disclosure data with IETF working group data.*** IETF's standards proposal and setting are organized under different technical areas. Currently, there are seven areas: Applications and Real-Time Area (art), General Area (gen), Internet Area (int), Operations and Management Area (ops), Routing Area (rtg), Security Area (sec), and Transport Area (tsv).[5] Under each technical area, many working groups are formed to tackle special technical problems and propose internet-draft, some of which will be finally approved as RFC. To map each disclosure to its technical area, we utilize this working group information and the title of internet-draft. As defined by IETF standards, the abbreviation of the working group should be

[5] A detailed introduction of the technical areas can be found at IETF website: https://www.ietf.org/topics/areas/

used in the file name (also as a unique id) of internet-draft. Thus, for specific disclosures with internet-draft id, we can identify the working group and further technical area. For disclosures with RFC number, we first trace its original internet-draft id from RFC documentary history, and then apply the same routing to identify the technical areas.

***Coding license terms.*** As described in Table 1, IETF explicitly provides six SEP declaration options for SEP owners to select, including "no license," "royalty-free," "royalty-bearing," "provided later," "unwilling to commit," and a free formatted "see below" option. Table 1 lists some examples of the license terms. Over 60% of disclosures are made under the option of "see below," along with customized licensing declarations. Also, the selection of options and the detailed license terms may be conflict. For example, a patent holder may select "royalty-bearing" but declare that free license may be provided under reciprocity. Thus, we codify license terms by text mining of detailed license declaration text and manual check. We classify "no license required," "royalty-free (no matter reciprocity required or not)" as royalty-free license, and other types of license terms as royalty-bearing (i.e. non-free). As shown in Table 1, IPR holders may include a reciprocal (grant back) licensing requirement for either royalty-free or royalty-bearing contract. This can either be indicated by some key phrases such as "subject to reciprocity" as illustrated in Telefonaktiebolaget LM Ericsson's license terms in Line 2 of Table 1, or in the form of defensive suspension clauses "(the licensor) will retain the right to retain the right to terminate the license and assert its patents against any licensee who assert any patent right against (the licensor) …" as illustrated in KDDI's license term in Line 6 of Table 1. Thus, we also codify a dummy variable, *reciprocity*, to indicate whether the patent holder requests reciprocal licensing. We match the license term using some regex expressions, including "recipro.*" and "provided that the licensee provides a.*" , as a first step to identify reciprocal license requirement and do manual check for more complex text patterns of license terms.

### 4.2. Measures

***Dependent variables.*** We define two variables to capture the key conditions of license terms, non-free and reciprocity.

*non-free*: a dummy variable equals 0 if the license term either requires no license or the patent holder claims not to assert any right against potential users or commit to grant a royalty-free license; equals 1 otherwise.

*reciprocity*: a dummy variable equals 1 if the patent holders the license terms, whether royalty-free or with a fee, is conditioned on reciprocate licensing; equals 0 otherwise.

***Explanatory variables.*** We employ the following five variables to capture technical and legal characteristics.

*n_uspc*: number of U.S. patent class code, which is a proxy variable for technical scope.

*rfc_cited*: a dummy variable equals 1 if the patent cites any RFC document or internet-draft; equals 0 otherwise.

*n_claim:* number of patent claims, which is a proxy variable for legal scope.

*duration:* remained life of the patent at the time of declaration in unit of years.

*family*: international patent family size.[6]

***Control variables.*** Two variables are used to control for prior knowledge usage in developing a SEP. *appl_citation:* number of backward citations made by applicants; *examiner_citation*: number of examiner citations made by examiners. We also include 6 technical area dummies and year period dummies to control for technical and year effects.

[6] We use the DocDB family size computed in PATSTAT 2017b database.

### 4.3. Descriptive Statistics

Table 2 shows the frequency of observations categorized by the two dependent variables—*non-free* and *reciprocity*. A reciprocal license is three times more likely to be requested if the patent holder commit free license of SEPs.

(TABLE 2 HERE)

(TABLE 3 HERE)

Table 3 presents descriptive statistics of major explanatory and control variables. In average, 59% of patents in the sample has cited RFC or internet-draft documents. The average duration of 15.80 years also shows that the patents are in the early years of their life at the time of IPR disclosure. In average SEPs has 26.18 claims, which is much higher than the average 15.33 claims of all US patent in the same period. Generally, the SEPs has an international patent family covering major patent authorities.

(TABLE 4 HERE)

Table 4 presents the correlations among independent variables. All the correlation coefficients are less than 0.25, indicating no obvious multicollinear problem.

## 5. RESULTS

Our empirical analysis includes two steps. The first step is to test whether technical factors and IPR strength affect patent holders' decision in committing free/non-free license terms. Then we test whether the two factors affect the incorporation of reciprocal requirements in license terms. The two analysis together would give a whole picture of how license terms in standard setting process maybe shaped by technical and legal factors. In both steps, we use logit model as both dependent variables are 0-1 dummies.

(TABLE 5 HERE)

Table 5 reports the estimation result with non-free as dependent variable. Column (1) includes control variables only; column (2) adds technical factors—*n_uspc* and *rfc_cited*; and

column (3) adds IPR factors—*n_claims*, *duration* and *family*. It is found that the coefficient to *family* is positive and statistically significant. An explanation is that firms have selected inventions with higher potential licensing values and applied patent protection in more countries. Thus, Hypothesis 4a is supported. However, we cannot get statistically significant coefficient to neither of coefficients to *n_uspc, n_claims* or *duration*. Thus, Hypothesis 1a, 2a and 3a are not supported. The independent variables used for this regression may be inappropriate or too weak as an indicator for technological and legal scope of patent.

(TABLE 6 HERE)

Table 6 reports the estimation with *reciprocity* as the dependent variable, while the independent variables remain the same with Table 5. In comparison, the coefficients of major explanatory variables are all significant. Column (2) shows that *n_uspc* are have a positive impact on *reciprocity*, supporting Hypothesis 1b. That is, patents with a wider application scope are more likely to be used in defensive license term settings. Column (3) shows that longer duration SEP is more likely to be licensed with a reciprocal licensing clause, supporting Hypothesis 2b. However, the coefficient of *n_claim* is not significant, failing to support Hypothesis 3b. As described in Section 4.3, generally SEPs have a large number of claims in average, thus the marginal contribution of additional claims in enlarging the legal scope may not be significant. The coefficient of *family* is minus and significant, supporting Hypothesis 5b.

(TABLE 7 HERE)

Furthermore, we have conducted the regression by interacting two dependent variables, non-free and reciprocate (Table 7) to test the remaining hypotheses. The model (1) and (2) are *non-free* as a dependent variable, for subsamples of *reciprocity*=0 and *reciprocity*=1, respectively. The model 3 and 4 are *reciprocity* as a dependent variable, for subsamples of *non-free*=0 and *non-free*=1, respectively.

As for the patent family, we have found robust results consistent to hypothesis 5a, regardless of reciprocal clause (model (1) and model (2)). In addition, the coefficient of *family* to *reciprocity* is even negative and statistically significant in case of free license clause (model (4)). This means more focused juridical coverage is correlated with existence of reciprocal clause for with royalty licensing declaration. Thus, Hypothesis 4c is supported.

It is found that the positive association of *rtc_cited* with *non-free* in the licensing declaration without reciprocal grant back clause, while such relationship is negative in the case of licensing declaration with reciprocal clause. A positive association between *rfc_cited* and *reciprocity* for free licensing contract is also found in the result of model (3). Thus, Hypothesis 5a and 5b are supported. The twisted results in model (1) and (2) can be interpreted as a contrasting nature of patent licensing, i.e., higher license fee for selected licensee or lower license fee for larger number of potential licensees (Dang and Motohashi, 2014). Ax-ante declaration of free licensing signals the licensor's intention of wider use of the technology (larger numbers of potential licensees), or expecting larger participants in this technology standard. However, as the technology is proliferated, a potential damage by hold-up by any competitor on the same standard becomes larger. Therefore, the patent based on existing standard (*rfc_cited*), a firm with free license is induced to keep the reciprocal grant back position (model (2) and model (3)). In contrast, licensing declaration with positive royalty fee (*non free*=1), such concern is smaller, so that we cannot find statistically significant results (model (4)).

A positive relationship between duration and reciprocate comes from licensing declaration of non-free=1 (model (4)), while we cannot find a statistically significant coefficient to *reciprocity* for the one of free license (model (3)). There may be due to the case that free licensing comes from any strategic reason, such as eco-system building, instead of its inherent patent value.

## 6. DISCUSSION AND CONCLUSION

We adopt such Georgia-Pacific factors as a research framework in our paper to examine SEP holders' decision-making about the declared RAND terms in their licensing commitments. This framework also incorporates the extant understandings and findings of patent characteristics and value from classical innovation literature (Harhoff et al., 2003; Lanjouw et al., 1998; Lanjouw & Schankerman, 2004; Lerner, 1994; Trajtenberg, 1990). Specifically, from both technical and legal aspects, we find that technical scope and reference to standard, together with IPR factors, such as duration of patents, shape the licensing strategies of patent holders in standard setting process, but the effect is not on the choice of royalty-bearing or not, but on the inclusion of reciprocal requirement in licensing terms. We also find that patent family size, which is usually interpreted as a simple indicator of patent value, have a subtle relationship with license terms in IPR disclosures relating to standard setting, unlike other value indicators. A large international patent family is generally a sign that the IPR holder is prone to appropriate its SEPs by a reasonable royalty, instead of royalty-free but with a reciprocal licensing clause.

Our study contributes to the literature in both standard setting (Bekkers et al., 2017; Chiao et al., 2007; Farrell & Saloner, 1985; Farrell & Simcoe, 2012; Kang et al., 2014; Layne-Farrar et al., 2007; Lerner et al., 2016; Rysman & Simcoe, 2008; Simcoe, 2012) and patent licensing (Arora & Fosfuri, 2003; Gambardella et al., 2007; Motohashi, 2008). First, the investigation on IETF is critical to the SSO literature especially those highlight IPR policy on RAND terms at SSOs (Bekkers et al., 2017; Layne-Farrar et al., 2007), given its relevantly weak focus on IPR policy in standardization owing to its origin that built upon a tradition of freedom, the spirit of Internet. In such a unique context, we find weak associations of technical and legal characteristics of a SEP with its holder's decision on licensing for free but strong associations with a reciprocal licensing term. Second, prior studies on patent licensing have often focused on licensing propensity and its determinants, based on a view that integrates both patent market

and product market (Arora & Fosfuri, 2003; Gambardella et al., 2007; Motohashi, 2008). Our paper further contributes to this line of research by examining specific license terms in the RAND context. These license terms are interesting because of the unique RAND context, where the decision-making implied by a licensing commitment from a patent holder may involve not only the holder's *ex ante* IPR strategy for technology market and product market but also court practices that would be key to determining patent value *ex post*. Moreover, our study provides a more reliable empirical base as the novel sample is collected from *real* licensing commitments at IETF, thereby extending the relevant studies that relied on nothing but self-reported survey data which may be biased (Arora & Fosfuri, 2003; Gambardella et al., 2007; Motohashi, 2008).

The current study may have practical implications for practitioners such as patent holders, decision-makers in SSOs, and court judges. First, patent owners who declare essentiality of its patents to standards, especially those who are new participants to any global SSO, need to learn how its IPR policy has influenced decisions in patent infringement lawsuits such as *Microsoft v. Motorala* (2012). Second, SSO policy-makers also need to keep improving their IPR polices and making sense of RAND commitments, to help technical area directors solve some potential problems such as a growing standard-setting time spent on reaching a *rough consensus* on a standard proposal (Farrell & Simcoe, 2012; Simcoe, 2012). Third, judges who face patent infringement cases may also benefit from the novel knowledge about SEP holders' incentives in determining specific RAND terms.

Yet, the current paper has the following limitations. First, we have not yet touched factors associated with downstream product market. A licensing propensity model that characterizes effects from both product market and technology market highlights the importance of firm characteristics such as size and complementary assets (Arora & Fosfuri, 2003). Explained by the model, survey data have also provided supportive evidences in Europe (Gambardella et al.,

2007) and Japan (Motohashi, 2008). Further studies on this issue, from both theory and empirical approach, will provide a good opportunity for our better understanding of RAND licensing terms at SSOs. Second, we find that the majority of licensing commitments in IETF includes reciprocal licensing clauses that explicitly indicate the condition of RAND terms. Currently, we are yet unclear about whether these clauses (or other defensive suspension clauses) conflict with the *non-discriminatory* principle of RAND, or perhaps there are different policy criterions across SSOs that focuses on distinct industries or technologies. Future research may work toward this direction to reach a better understanding on this important issue. Third, and finally, we have not incorporating the interactions of multiple IPR holders regarding to a single RFC or internet-draft. It is likely that licensing terms of the pioneering disclosure may affect the decisions of other following IPR holders. Furthermore, there should be substantial strategic interactions between competitors among technology standard making process ( Future studies may apply a dynamic model to shedding light on the chaining disclosure strategies.

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**Table 1. The RAND terms in licensing commitments at IETF**

| Types of RAND terms | Examples of RAND terms |
|---|---|
| No license | No license required for implementers. |
| Royalty-free | AIST (National Institute of Advanced Industrial Science and Technology) is prepared to grant a license under a contract with reasonable terms, conditions and royalty. But, if this document (RFC 6628, draft-shin-tls-augpake-xx) is adopted as an IETF standards track RFC, AIST is prepared to grant a non-exclusive royalty-free license for any conforming implementations of the adopted version (as an IETF standards track RFC) of this document (RFC 6628, draft-shin-tls-augpake-xx). Needless to say, this does not mean that all the claims and the contents in the patent application PCT/JP2009/062578 are covered with the non-exclusive royalty-free license. |
| Royalty-bearing | In case a license to a patent in the patent family above or a patent issued/granted on an application for a patent on the invention above should be necessary for implementing any standards-track IETF document , Telefonaktiebolaget LM Ericsson is willing to grant to anybody a license to such patent on fair, reasonable and non-discriminatory conditions for the implementation of the standards-track document, subject to reciprocity. |
| Provided later | Licensing declaration to be provided later. |
| Unwilling to commit | No information submitted |
| Defensive suspension (e.g. no license or royalty-free upon reciprocity, else royalty-bearing upon non-reciprocity; termination right upon non-reciprocity) | No License Required for Implementers. KDDI Corporation will retain the right to terminate the license and assert its patents (including the right to claim past royalties) against any licensee that asserts or whose affiliate asserts any patent (either directly or indirectly) against KDDI Corporation or any of KDDI Corporation's affiliates or successors in title. |

Nokia agrees not to assert those claims in Nokia above mentioned patents that apply to the RFC3588 and are technically necessary to implement this IETF standard specification against any other party in respect of its implementation of the specification, provided that the party relying on this commitment does not assert its patents against Nokia.

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**Table 2. Category of license terms**

| | *reciprocity* | | |
|---|---|---|---|
| *non-free* | 0 | 1 | Total |
| 0 | 112 | 433 | 545 |
| 1 | 230 | 230 | 460 |
| Total | 342 | 663 | 1,005 |
| | | | |
| Pearson | chi2(1) = 96.3691 | | Pr = 0.000 |

**Table 3. Descriptive statistics of independent variables**

| Variables | N | Mean | SE | Min | Max |
|---|---|---|---|---|---|
| *n_uspc* | 1003 | 3.07 | 2.58 | 1 | 23 |
| *rfc_cited* | 1005 | 0.59 | 0.49 | 0 | 1 |
| *duration* | 1005 | 15.80 | 3.41 | 2.68 | 20 |
| *n_claim* | 1005 | 26.18 | 16.21 | 1 | 145 |
| *family* | 1005 | 5.59 | 5.85 | 1 | 51 |
| *appl_citation* | 1005 | 5.02 | 22.62 | 0 | 227 |
| *examiner_citation* | 1005 | 4.27 | 5.64 | 0 | 53 |

**Table 4. Correlation matrix of independent variables**

| Variables | | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| *n_uspc* | (1) | 1.000 | | | | | |
| *rfc_cited* | (2) | -0.013 | 1.000 | | | | |
| *duration* | (3) | -0.114 | 0.214 | 1.000 | | | |
| *n_claim* | (4) | 0.043 | -0.011 | -0.174 | 1.000 | | |
| *family* | (5) | -0.016 | -0.084 | -0.045 | 0.084 | 1.000 | |
| *appl_citation* | (6) | -0.058 | 0.074 | 0.136 | 0.130 | 0.135 | 1.000 |
| *examiner_citation* | (7) | 0.187 | -0.032 | -0.195 | 0.154 | -0.008 | -0.001 |

**Table 5. Logit regression on determinants of non-free**

| | (1) *non-free* | | (2) *non-free* | | (3) *non-free* | |
|---|---|---|---|---|---|---|
| *n_uspc* | | | 0.00559 | (0.21) | 0.0103 | (0.37) |
| *rfc_cited* | | | -0.115 | (-0.83) | -0.0528 | (-0.37) |
| *n_claims* | | | | | -0.00900 | (-1.95) |
| *duration* | | | | | -0.0185 | (-0.70) |
| *family* | | | | | 0.0779*** | (5.76) |
| *appl_citation* | -0.0183** | (-2.89) | -0.0181** | (-2.85) | -0.0222** | (-3.11) |
| *examiner_citation* | 0.00519 | (0.43) | 0.00481 | (0.40) | 0.0102 | (0.80) |
| *art* | 1.033*** | (4.26) | 1.026*** | (4.22) | 0.824** | (3.28) |
| *int* | 0.245 | (0.85) | 0.262 | (0.91) | 0.214 | (0.73) |
| *ops* | 0.792** | (2.69) | 0.805** | (2.72) | 0.735* | (2.45) |
| *rtg* | -0.235 | (-1.34) | -0.217 | (-1.23) | -0.267 | (-1.48) |
| *sec* | -0.262 | (-0.87) | -0.272 | (-0.90) | -0.454 | (-1.43) |
| *tsv* | -0.0129 | (-0.05) | -0.0190 | (-0.08) | -0.366 | (-1.42) |
| *y01_05* | -0.756** | (-3.19) | -0.735** | (-3.09) | -0.754** | (-2.95) |
| *y06_10* | -0.710** | (-2.93) | -0.699** | (-2.87) | -0.682* | (-2.40) |
| *y11_16* | -1.060*** | (-4.06) | -1.021*** | (-3.83) | -0.894** | (-2.69) |
| *Constant* | 0.504* | (2.06) | 0.531* | (1.98) | 0.620 | (1.44) |
| Observations | 1005 | | 1003 | | 1003 | |
| LR $\chi^2$ | 81.04 | | 81.74 | | 122.9 | |
| Pseudo $R^2$ | 0.0585 | | 0.0591 | | 0.0889 | |

*t*-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 6. Logit regression on determinants of reciprocity**

| | (1) *reciprocity* | | (2) *reciprocity* | | (3) *reciprocity* | |
|---|---|---|---|---|---|---|
| *n_uspc* | | | 0.0834* | (2.55) | 0.0768* | (2.30) |
| *rfc_cited* | | | 0.720*** | (4.86) | 0.670*** | (4.34) |
| *n_claim* | | | | | -0.00224 | (-0.47) |
| *duration* | | | | | 0.0695* | (2.47) |
| *family* | | | | | -0.0862*** | (-5.95) |
| *appl_citation* | -0.00604 | (-1.64) | -0.00695 | (-1.85) | -0.00571 | (-1.42) |
| *examiner_citation* | -0.000383 | (-0.03) | -0.00533 | (-0.40) | -0.00721 | (-0.51) |
| *art* | -1.032*** | (-4.49) | -0.955*** | (-4.07) | -0.724** | (-2.99) |
| *int* | 0.158 | (0.49) | 0.133 | (0.40) | 0.166 | (0.49) |
| *ops* | -1.303*** | (-4.51) | -1.333*** | (-4.51) | -1.321*** | (-4.41) |
| *rtg* | 0.531* | (2.54) | 0.484* | (2.27) | 0.492* | (2.27) |
| *sec* | -0.250 | (-0.81) | -0.201 | (-0.64) | -0.0314 | (-0.10) |
| *tsv* | -1.569*** | (-6.35) | -1.502*** | (-5.95) | -1.271*** | (-4.78) |
| *y01_05* | 0.494* | (2.06) | 0.413 | (1.69) | 0.264 | (1.01) |
| *y06_10* | 0.453 | (1.84) | 0.384 | (1.54) | -0.0229 | (-0.08) |
| *y11_16* | 0.681* | (2.54) | 0.642* | (2.31) | -0.000574 | (-0.00) |
| *Constant* | 0.519* | (2.09) | -0.0607 | (-0.22) | -0.283 | (-0.64) |
| Observations | 1005 | | 1003 | | 1003 | |
| LR $\chi^2$ | 125.5 | | 156.7 | | 201.0 | |
| Pseudo $R^2$ | 0.0974 | | 0.122 | | 0.156 | |

*t*-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 7. Logit regression with sub datasets**

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| | *reciprocity* =0 | *non-free* | *reciprocity* =1 | | *non-free* =0 | *reciprocity* | *non-free* =1 | |
| *n_uspc* | 0.00270 | (0.04) | 0.0212 | (0.64) | 0.131* | (2.13) | 0.0723 | (1.72) |
| *rfc_cited* | 1.822*** | (5.28) | -0.501** | (-2.66) | 1.503*** | (4.97) | 0.169 | (0.81) |
| *duration* | -0.0495 | (-0.97) | 0.0524 | (1.41) | -0.0411 | (-0.73) | 0.0947** | (2.62) |
| *n_claim* | 0.00684 | (0.82) | -0.0150* | (-2.15) | 0.0101 | (1.12) | -0.00958 | (-1.46) |
| *family* | 0.110*** | (4.35) | 0.0761*** | (3.68) | -0.000709 | (-0.02) | -0.0925*** | (-4.45) |
| *appl_citation* | -0.0301** | (-2.77) | -0.0281* | (-2.21) | -0.0111* | (-2.11) | -0.0109 | (-0.83) |
| *examiner_citation* | 0.0288 | (1.15) | 0.0128 | (0.73) | -0.0211 | (-0.79) | 0.00253 | (0.13) |
| *gen* | 0 | (.) | 0 | (.) | 0 | (.) | 0 | (.) |
| *art* | -0.00448 | (-0.01) | 1.070** | (3.10) | -1.259** | (-2.84) | -0.0141 | (-0.05) |
| *int* | 0.725 | (0.84) | 0.350 | (0.99) | 0.363 | (0.45) | 0.336 | (0.80) |
| *ops* | 0.149 | (0.28) | 0.256 | (0.56) | -0.993 | (-1.78) | -1.098** | (-2.67) |
| *rtg* | 1.406* | (2.27) | -0.332 | (-1.48) | 1.646** | (2.93) | 0.0821 | (0.28) |
| *sec* | -1.737** | (-2.60) | -0.605 | (-1.43) | -0.150 | (-0.28) | 0.213 | (0.43) |
| *tsv* | -2.852*** | (-6.06) | 1.425*** | (3.48) | -3.119*** | (-6.70) | 0.0447 | (0.12) |
| *y01_05* | -1.106* | (-2.19) | -0.713* | (-2.09) | 0.243 | (0.42) | 0.109 | (0.33) |
| *y06_10* | -0.417 | (-0.73) | -0.894* | (-2.35) | 1.015 | (1.55) | -0.337 | (-0.90) |
| *y11_16* | -1.105 | (-1.63) | -1.436** | (-3.21) | 1.321 | (1.81) | -0.612 | (-1.38) |
| Constant | 1.108 | (1.38) | -0.375 | (-0.61) | 0.447 | (0.48) | -0.682 | (-1.19) |
| Observations0 | 342 | | 661 | | 544 | | 459 | |
| LR $\chi^2$ | 130.7 | | 91.24 | | 201.5 | | 53.88 | |
| Pseudo $R^2$ | 0.302 | | 0.107 | | 0.364 | | 0.0847 | |