Hitotsubashi University
Institute of Innovation Research

The Screening Function of International Search Authorities under the Patent Cooperation Treaty: Evidence from the Japanese Government's Policy Change in 1999

Okada, Yoshimi

IIR Working Paper WP#20-13

July 2020

Institute of Innovation Research
Hitotsubashi University
Tokyo, Japan
http://www.iir.hit-u.ac.jp

The Screening Function of International Search Authorities under the Patent Cooperation Treaty: Evidence from the Japanese Government's Policy Change in 1999

Yoshimi Okada[a]

[a]Hitotsubashi University, Institute of Innovation Research, 2-1 Naka, Kunitachi, Tokyo 186-8601, Japan.

July 20, 2020

Abstract

This article examines the screening function of the International Search authorities, which produce International Search Reports (ISRs) for international patent applications filed under the Patent Cooperation Treaty. It first reveals that the patent examination policy change from quantity-oriented to quality-oriented by the Patent Office of the Japanese government in 1999 increased the number of references cited in ISRs significantly. It uses this unexpected drastic policy change as an instrument for the quality of ISRs and finds that the effect of improving the quality of ISRs on the applicant's decision to enter the national/regional phase procedure is significant, resulting in decrease in the entrance rates, by four percent for the United States national phase procedure and six percent for European regional phase procedure. Thus, the examination policy change made the information provided by ISRs on prior art become significantly more useful to applicants (e.g., more findings of unexpected prior art) and thus enhanced the screening function of ISRs significantly. The estimated coefficients of improving the quality of ISRs are more than ten times larger than those estimated by using the ordinary least squares method (OLS), showing that the endogeneity of examiner's citations with respect to the patenting value is so significant that it leads to substantial underestimations by using the OLS.

Keywords: Screening; International Search Report; Patent Cooperation Treaty; prior art search; quality of patent examination; patent examination policy change

JEL classification: O34, O38, K29

Highlights

- Japan’s patent examination policy became quality-oriented in 1999.
- Quality-oriented patent examination caused a significant rise in search quality.
- Significant effect of quality improvement in prior art search on applicants.
- A rise in International Search Report quality enhanced the screening function.
- Japan’s policy change contributed to an efficient global patent examination system.

1. Introduction

There are two alternative ways in which to obtain a foreign patent. The first way is to file a patent application directly to a foreign patent authority. The second way is to file an international patent application to the patent authority of the applicant's own country under the Patent Cooperation Treaty (PCT) and designate the countries or regions in which he/she wants to obtain patents as the "designated countries." Under the first approach, a patent applicant must file a patent application, written in the foreign language, to the foreign patent authority within 12 months of the original patent application date if he/she wants to hold the priority right. By contrast, under the PCT international patent filing system, an applicant can postpone the due date of submitting the translation to the foreign patent authorities as late as 30 months after the priority date[1]. Further, the applicant is provided with an International Search Report (ISR) by an International Search Authority (ISA)[2], which enables him/her to estimate the possible scope of the patent right as well as the possibility of acquiring a patent, assess whether to bear the additional cost including the cost of translating the application documents into the foreign language(s), and screen out applications of little value. This study focuses on this screening function of an ISA and ISRs.

From the viewpoint of global patent examination authorities, the PCT system offers two advantages for increasing the efficiency of global patent examination. The first is that patent examination authorities can use the prior art information cited in ISRs to examine PCT patent applications under their respective subsequent examination procedures, which they call "national phase" or "regional phase." The Trilateral Patent Offices (i.e., the European Patent Office (EPO), the Japan Patent Office (JPO), and the United States Patent and Trademark Office (USPTO)) have investigated the utility of ISRs, confirming that they are beneficial to patent authorities that examine PCT patent applications entering the national/regional phase, although the details are not publicly available (Trilateral Patent Offices, 2001, 2002). The second advantage is that the screening function of the ISAs and the ISRs reduces the number of patent applications that each patent authority must examine since applicants do not submit the translation(s) of some PCT applications and those applications do not enter the national/regional phases.

According to WIPO (WIPO, 2020 and WIPO, 2015a), the number of PCT applications filed globally in 2019 was around 266,000, about triple the 93,000

[1] There was a legal change in the PCT system in 2003. Before 2004, the due date was 20 months from the priority date.

[2] The objective of the international search is "to discover relevant prior art" and the ISA "endeavors to discover as much of the relevant prior art as its facilities permit" (15.01 of (WIPO, 2015b)).

applications filed in 2000 and more than 10 times the 20,000 applications filed in 1990. In 2019, Japanese residents filed 52,700 PCT applications, more than five times the 9,600 applications filed in 2000 and more than 30 times the 1,700 applications filed in 1990. Thus, the use of the PCT system has been increasing significantly in the past three decades to become the main route for obtaining foreign patents. This trend has meant that it is now increasingly important to enhance the screening function of ISA's and ISR's to maximize the efficiency of the global patent examination system.

Despite the importance of an ISA's and an ISR's screening function, no prior study, to the best of my knowledge, has addressed this matter. Based on this gap in the body of knowledge on this topic, this article reveals the significance of the information provided by ISRs to applicants and investigates whether improving the quality of ISRs affects applicants' decision to enter the national/regional procedure. However, investigating the effects of the quality of ISRs on applicants' decision is challenging for two main reasons.

The first difficulty is that there is no established way of measuring the quality of ISRs. In 1999, the examination policy of the JPO veered suddenly from quantity-oriented to quality-oriented[3], which led to a dramatic rise in the number of citations in the ISRs that deny the patentability of filed inventions. Based on this finding, the quality of ISRs is quantified by measuring the number of cited documents that deny the novelty or inventive step of at least one of the claims.[4]

The second difficulty is the problem of endogeneity. My hypothesis is that the number of citations made by an examiner in an ISR to deny the patentability of the filed inventions, which serves as a proxy for the quality of an ISR, affects negatively the applicant's decision to enter the national/regional phase procedure. However, because the number of the examiner's backward citations is positively correlated with the economic value of the patent (Allison et al., 2003; Harhoff et al., 2003) and the economic value affects positively the applicant's decision to enter the national/regional phase procedure in designated countries, the coefficient of the number of examiner citations estimated by using the ordinary least squares (OLS) method is likely to be positively biased (that is, smaller in absolute values). In addition, other factors are assumed to affect the applicant's decision, such as the possible obsolescence of the invention and an applicant's ex-post discovery of prior art after filing a PCT application, both of which might be correlated positively with the number of the examiner's

[3] Because the policy was not well publicized, the precise date is unknown.

[4] The scope of exclusive right is defined in "claims" of patent application documents. An application usually contains two or more claims.

backward citations and negatively affect the decision to enter the national/regional phase.

Fortunately to perform an empirical study, the policy change made by the JPO in 1999 was not announced in advance and was not well publicized even afterward. The change, therefore, did not affect the quality of patent applications immediately after the change, but rather provided an exogenous shock to the citations in the ISRs. This article, hence, exploits this exogenous shock as an instrumental variable for the quality of ISRs to investigate the research question posed above.

In the past decade, governments in major countries have been emphasizing on the importance of the quality of patents in order to promote innovation. In 2013, the Economic and Scientific Advisory Board of the EPO, for instance, recommended improving the patent system and highlighted the importance of patent quality in boosting innovation. In Japan, the Cabinet decided in July 2014 to aim to achieve the highest quality patent examination in the world through several measures including the introduction of an objective quality management system. In 2015, the USPTO launched its “Enhanced Patent Quality Initiative,” which consists of comprehensive measures to improve patent examination. In 2016, the United States Government Accountability Office (USGAO) recommended that the USPTO define quality and strengthen search capabilities (USGAO, 2016a, 2016b). Thus, it has been one of the top priority tasks for these patent offices to provide high quality patent examinations.

One of the most important factors that affect patent examination quality is the extent of the comprehensiveness of prior art search (Federal Trade Commission, 2003; Jaffe & Lerner, 2004; Merrill et al., 2004; USGAO, 2013, 2016a). To the best of my knowledge, no empirical study, however, has thus far provided evidence for the tangible effect of improving the quality of prior art search on the outcome of patent examinations.

The major findings of this study can be summarized as follows. The JPO’s drastic examination policy change from quantity-oriented to quality-oriented in August 1999 led to a dramatic rise in the number of several types of documents cited in ISRs. After the JPO’s policy change, the rate of the entrance of the national/regional phase procedure decreased by 4% for US and by 6% for Europe. This study uses the unexpected policy change as an instrument for the quality of ISRs and finds that the effects of improving the quality of ISRs on the applicant’s decision to enter the national/regional phase procedure are statistically significant with large values: a 10% increase in quality causes a 4% decrease in entering the US national phase procedure and a 6% decrease in entering the European regional phase procedure. The information provided by ISRs on prior art thus became significantly more useful to patent applicants. Further, the estimated effects of this quality improvement in ISRs were far more than 10 times those estimated by using the OLS method, suggesting that the value of patenting overseas is strongly correlated with the number of the examiner's backward citations and the OLS estimation substantially underestimates the screening function of the ISRs. The information revealed by ISRs seems to be significantly unanticipated to the applicants to affect greatly their decision to enter the national/regional phase. The 1999 quality-oriented policy change by the JPO hence improved the quality of prior art search, thereby enhancing the screening function of the ISA and ISR's and raising the efficiency of the global patent examination system.

The remainder of this paper is organized as follows. Section 2 describes the institutional background and prior literature and formulates the hypotheses; Section 3 describes the data construction, variables, and estimation models; Section 4 presents the results and discussion; and Section 5 concludes.

2. Institutional background, prior literature, and hypotheses development

2.1. Prior art information in ISRs under the PCT system

Under the PCT system, an applicant living in Japan can file a patent application written in Japanese to the JPO or the International Bureau and the JPO prepares an ISR as the ISA[5]. An ISR is usually prepared within three months of receiving the application if the application claims priority based on earlier patent application(s)[6].

An ISR contains a list of references with citation category information that indicates the examiner's patentability assessment of each claim. The major citation categories are "X," "Y," "A," "P," and "E." The symbol "X" is indicated when the claimed invention cannot be considered to be novel or to involve an inventive step when the prior art is taken alone. The symbol "Y" is given if the claimed invention cannot be considered to involve an inventive step because the claimed invention is the combination of two or more pieces of prior art and such a combination is obvious to a person skilled in the art. The symbol "A" means that the document is not considered to deny the novelty or inventive step of the claimed invention. The symbol "E" is given to an earlier application or patent published on or after the international filing date of the focal PCT application. The symbol "P" denotes that the document was published before

[5] If an application is written in English, the applicant can designate the JPO or EPO as the ISA. This study only deals with PCT applications written in Japanese.

[6] Rule 42 of the Regulations under the PCT stipulates that the time limit for establishing the ISR shall be three months from the receipt of the search copy by the ISA or nine months from the priority date, whichever time limit expires later.

the international filing date but later than the priority date claimed by the focal PCT application. The document category “E” and “P” is given in combination with a symbol indicating the relevance of the document (e.g., “P, X”, “P, Y” or “P, A”). In this study, references to categories of both “P” and “E” are ignored for simplicity because these kinds of documents are treated as prior art only when they had been filed in the jurisdiction in question[7], and the legal effects of these references differ by jurisdiction[8].

Because one application usually contains two or more claims, two or more categories may be assigned to one reference as in the case in which a document is assigned to category X in light of claim 1 and to category Y in light of claim 2. In this study, for simplicity, the references are categorized as follows: “X document” if “X” is assigned in light of at least one claim; “Y document” if “Y” is assigned in light of at least one claim and no “X” is assigned; and “*A* document” if “A” is assigned in light of at least one claim and no “X” or “Y” is assigned. “X documents” and “Y documents” are hereinafter collectively called “XY documents.”

Although the references in ISRs are beneficial for reducing the workload needed to process the application by other offices in the national/regional phase (Trilateral Patent Offices, 2001, 2002), a significant amount of prior art documents are added through the national/regional phase examination process in each designated country; hence, there seems to be room for improvement in the quality of ISRs (JPO, 2013).

The screening function will not be boosted, however, by improving the quality of ISRs if the prior art information provided by an ISR is practically useless to the applicant because of such factors as wide differences in legal systems and in the standards of patent grants, as suggested by Jensen et al. (2005) and Webster et al. (2007)[9]. Further, the amendment of claims in a patent examination procedure may be significant compared with the denial of the patentability of the initial claims[10]. It is therefore an important empirical issue to examine whether improving the prior art information provided by an ISR affects the applicant’s decision to enter the

[7] A prior application of “E, X” or “E, Y” filed only to Japan cannot be considered to be a prior art under US patent law or the EPC.

[8] In the United States, the combination of “EY” category documents can deny the inventive step of the filed invention; however, the combination of “EY” category documents is not allowed under the European and Japanese patent systems.

[9] Jensen et al. (2005) and Webster et al. (2007) investigated patent applications filed to the EPO, JPO, and USPTO between 1990 and 1995 and concluded that the examination outcome is inconsistent among these offices. However, this research did not take account of the difference in the quality of prior art search among the corresponding patent applications.

[10] Applicants can narrow the scope of exclusive right by amending the initial claims in the respective patent examination procedure in each national/regional phase.

national/regional phase.

2.2. Prior literature

The JPO (2011, 2013) investigated the types and number of prior art documents cited by national/regional patent offices by using sample of 3,597 PCT applications for which ISRs are prepared by the JPO and 5,311 PCT applications for which ISRs are prepared by the USPTO, both with a filing date in 2004–2005. It revealed that a significant amount of prior art documents is added through the national/regional examination process in each designated country.

Wada (2016) scrutinized a large sample of PCT applications with filing dates in 2002–2005 of which ISRs were produced by the EPO, the JPO, or the USPTO and entered the three national/regional examination processes to investigate whether geographical distance affects the probability of finding prior art at the time of preparing an ISR. It revealed that geographical distance as well as the technological complexity of the filed inventions negatively affect the probability of finding prior art patent documents.

Wada (2014) is a pioneering study that used a quantified quality indicator of an ISR. The indicator is based on the measurement of the ratio of the number of citations cited in the ISR to the total number of citations cited by the ISR, the EPO, the JPO, or the USPTO. The quality of an ISR, however, cannot be measured by the proposed indicator if the application did not enter the national/regional phase procedure and there are not US or European corresponding patent applications. Thus, improving the quality of ISRs may not necessarily increase the average value of the proposed indicator if applications with high quality ISR’s tend not to enter the national/regional phase procedure and drop from the sample. It is therefore necessary to investigate whether and to what extent improving the quality of an ISR affects the applicant’s decision to enter the national/regional procedure in each designated country to reveal the efficacy of the proposed indicator.

Lemley (2001) estimated the cost incurred by patent holders including litigation cost, assuming that the number of patents reduces by 10% if the USPTO doubles the amount of time examiners spend reviewing a patent from the current 18 hours to 36 hours. He found that it is not cost effective to improve examination quality. Further, he emphasized that very few patents were ever the subject of litigation, or even licensing, and that 95% of the patents issued were either never used or were used in circumstances that did not crucially rely on the determination of validity, suggesting rational ignorance on the part of the USPTO. He concluded that little money should be spent in the examination process at the USPTO and comments on the need to strengthen the validity inquiry by trial courts.

Cockburn et al. (2002) investigated 182 US patents, the validity of which the Court of Appeals for the Federal Circuit (CAFC) ruled on in 1997–2000. For each patent, they identified the USPTO primary examiner and collected historical statistics such as each examiner's average "approval time" (i.e., the average time between initial application and patent issue) and "three-month volume of patents" (i.e., the count of issued patents in the three months before the issue date of the focal patent). By using these two parameters, they found no evidence that workload affects the probability of the CAFC finding a patent invalid. They stated that efforts to improve the visible aspects of the examination process can create long-lasting and subtle changes on the less easily measured aspects of the examination process. This study had a fundamental problem, however, in that a long "approval time" and low "three-month volume of patents" do not necessarily always mean that the examiner had a larger allocation of time and low workload, rather, these factors may mean that the patent applications are potentially controversial and require examiners more processes and more time for them to examine points at issue carefully.

De Saint-Georges and Van Pottelsberghe de la Potterie (2013) presented a quality index for patent systems composed of nine operational design components that shape the transparency and stringency of patent systems and affect the extent to which they comply with patentability conditions. Seven components are related to rules and regulations (e.g., grace period, opposition process, and continuation-in-parts), while two components measure patent offices' resource allocation policy (i.e., workload per examiner and incentives). They investigated 32 national patent systems, and through cross-sectional quantitative analyses, showed that demand for patent rights is lower in patent systems with a higher quality index, controlling for research efforts, patent fees, and the strength of enforcement mechanisms. This study, however, is not an empirical study based on micro-level data.

Yamauchi and Nagaoka (2015) has investigated the effects of outsourcing of prior art search on the patent examination, using a large scale Japanese patent examination data controlling for the endogeneity of outsourcing decision as well as the changes in the time resources available for an examiner to find that the outsourcing of prior art search significantly decreases the frequency of appeals against both examiners' rejections and grant decisions and reduces the length of examination duration.

Nagaoka and Yamauchi (2017) has examined how initiation timing of patent examination affects the quality of patent examination by exploiting the law change in

Japan, which shortened the maximum allowed time for examination request from seven to three years in 2001, and thus accelerated the timing of examination. It has found that acceleration of the timing of patent examination increased significantly both the grant rate and the frequency of appeals against the rejections of the patent office. These results reveal that more information constraint increases both type I and type II errors (wrong grants and wrong rejections), but the increase in wrong grants is dominant. These effects become stronger in technology sectors which have both short technology cycles and early examination requests. It concludes that the findings suggest that the patent office is under prior-art-information constraint.

Kim and Oh (2017) has empirically investigated effects of examination workloads at the Korean Patent Office on the patent examination outcome and validity of patents, using Korean patent micro-level data to find that examiner decisions to grant patents are systematically biased as workload increases, with examiners being more likely to grant a patent than to reject it., and the likelihood of grant decision reversal by invalidation trial boards significantly increases as workload increases. It concludes that these results imply that an examiner who lacks sufficient time for a prior art search tends to grant a patent and, consequently, a large workload decreases the quality of examinations by resulting in unqualified patents.

Frakes and Wasserman (2017) has addressed the question whether the time allocated for reviewing patent applications to each examiner affects patent grant decisions using application-level data to trace the behavior of individual examiners in the USPTO over the course of a series of promotions that carry with them reductions in examination time allocations. It has found that such promotions are associated with increases in granting tendencies, decreases in the share of total prior art citations listed in the final patent that derive from the examiner as opposed to the applicant, and decreases in the likelihood of allowance at the EPO or the JPO.

These above four studies, however, has not investigated direct influences of increase in quality or intensiveness of prior search on the outcome of patent examination. In summary, despite the importance of the screening function of the ISA's and ISR's, no prior study has thus far addressed this matter or showed the direct effects of improving the quality of prior art search empirically.

2.3. Drastic change in the JPO's patent examination policy in 1999

As discussed previously, this study hypothesize that an exogenous shock in the quality of ISR's made by the JPO as an ISA was caused by the unexpected drastic policy change by the JPO from quantity-oriented to quality-oriented in 1999. To reveal that there was actually a policy change in 1999, it first reviews documents relating to the JPO’s examination policy.

In 1998, the patent examination policy was oriented to quantity, known as the “FA12 policy,” which meant taking the first office action within 12 months of the request for examination by the end of 2000. This policy was officially announced on December 25, 1997 (JPO, 1998).[11] Sasaki (1999) published on January 14, 1999 describes Deputy Commissioner Sasaki’s view of the prospect of accomplishing “FA12” by the end of year 2000.

During 1999, however, the policy was switched to one that focused on the quality of search and examination. Ishii (2000), which was written by Deputy Commissioner Ishii and published in January 2000, did not refer to the “FA12 policy” but rather to the “quality of search and examination.” Ogiya (2000), which was written by the Director of the Patent Examination Policy Planning Office, emphasizes the importance of raising the quality of search and examination and does not refer to the speed of patent examination. Keidanren (2000) was an article based on an interview with Mr. Kozo Oikawa, Commissioner of the JPO, in a magazine published by the Japan Business Federation, a comprehensive economic organization with a membership of more than 1,000 Japanese companies. This article refers to Commissioner Oikawa’s intention to realize a “search and examination in quality comparable to that of foreign counterparts” and does not refer to “FA12.”

Sasaki (1999), Ishii (2000) and Ogiya (2000) were articles in *Tokugikon*, which is the magazine published by *Tokkyo-gijutsu-konwakai*, the association of the JPO’s examiners, shows that the examination policy is different between January 1999 and January 2000.

Next, this article presents evidence based on statistical data. Fig. 1A presents the average number of foreign patent documents cited in ISRs that have no patent families written in Japanese, calculated by the calendar month of the filing date[12]. The value jumped to a relatively high value of around 0.13 after August 1999, whereas the number was small before August 1999 (around 0.6). Fig. 1B presents the average number of non-patent literature (NPL) documents cited in ISRs. There seems to be a

[11] Before the FA12 policy started, the examination policy was also quantity-oriented, known as “Plan 24,” which meant reducing the backlog of pending applications below the amount of work of 24 months by the end of 1995. The “FA12” policy emphasized further the speed of patent examination.

[12] Applications are restricted to applications that designated the United States as the designated country. Applications of co-ownership and applications claiming no priority are removed. Applicants are restricted to those that have 10 or more applications between fiscal year (FY) 1998 and FY2000. The fiscal year of Japan runs from April to March in the following year. (See section 3.1)

leap around August 1999. Figs. 1C and 1D present the average number of X and XY documents, respectively, highlighting the small jump right after August 1999. The international filing date is used as horizontal axes in the figures, as the precise date on which an ISR was prepared for each application is unavailable. As an ISR is usually prepared within three months of the international filing date and the dates on which the ISRs were created range between one and two months considering the clerical work operation time, some ISRs may have been created under the former policy and others under the new policy even though the international filing dates are the same, which will make the slopes gentler[13]. These results indicate that the JPO's unexpected policy change really occurred in 1999 and the date is probably between August and September in 1999. Later, this article carries out a regression analysis, controlling for the variables that relate to the quality and volume of the inventions in PCT applications.

(Fig. 1 around here)

Fig. 2 presents the change in the number of examiners in the JPO including assistant examiners as well as the number of first actions made and number of grant decisions. The number of patent examiners including assistant examiners changed little around this period. Because only a tenth of the first actions are decisions to grant[14], most grant decisions are made as second or subsequent actions. Both the number of first actions and the number of grant decisions decreased after the policy change, suggesting that the examination policy change brought about a drop in output and that the quality improvement is driven by allocating more time for the examination of each application.

(Fig. 2 around here)

2.4. Hypotheses development

This study aims to reveal the significance of the quality of prior art information provided by ISR's for applicants and investigates whether the improvement in the quality of an ISR affects the applicant's decision to enter the national/regional phase; hence, the main hypothesis is set as follows:

Hypothesis H1: Improving the quality of the prior art information provided by ISRs reduces the rate of applicants' decision to enter the national/regional phase significantly, controlling for endogeneity with respect to the characteristics of applications that may correlates with the value of patenting overseas such as the quality and volume of the

[13] It often takes time for an examiner to obtain a copy of the NPLs from libraries, which might explain why the onset of the leap in the NPL is earlier than that of another citation.

[14] According to *Tokugikon* Study Group on examination quality (2012), 11% of the first actions are decisions to grant.

inventions in PCT applications.

(Fig. 3 around here)

This study hypothesizes that the drastic patent examination policy change by the JPO in 1999 caused a leap in the number of citations in ISRs. Fig. 3 presents the trend of PCT applications received by the JPO by calendar month, showing the number almost doubled from the beginning to the end of the study period, April, 1998 to March, 2001; hence, the characteristics of applications such as the number of claims in PCT applications might have changed over time. Sub hypothesis H1a relates to whether that observed in Fig. 1 is supported if we control for the characteristics of applications such as the quality and volume of the inventions contained in PCT patent applications.

Sub hypothesis H1a: The JPO's 1999 patent examination policy change increased dramatically the numbers of such citations in ISRs as 1) foreign patent documents that have no patent families written in Japanese, 2) NPL documents, 3) X documents, and 4) XY documents, controlling for the quality and volume of the inventions in PCT applications.

(Fig. 4A and Fig. 4B around here)

If an ISR provides the applicant with significant information about the prior art that denies the novelty or inventive step of claimed inventions and the quality of such information rises, the rate of entering the national/regional phase will drop. Figs. 4A and 4B present the rate of entering the US national phase and the European (also termed EP hereafter) regional phase by calendar month, respectively. Both values dropped after the examination policy change. Sub hypothesis H1b relates to this in the reduced form of the quality variable for each ISR. In other words, it relates to whether what we observe in Fig.4A and Fig. 4B is supported if we control for the quality and volume of the inventions contained in PCT applications.

Sub hypothesis H1b: The rate of entering the US national phase or EP regional phase of PCT applications for ISRs prepared by the JPO reduced dramatically after the JPO's 1999 unexpected patent examination policy change, controlling for the quality and volume of the inventions in PCT applications.

3. Data construction and estimated model

3.1. Data construction

We developed a novel database of PCT applications that contains information about designated countries and national/regional phase entrance for each application as well as the citations cited in each ISR.

First, we took PCT application data including bibliographic data and citation data from the PATSTAT database provided by the EPO (2015 autumn version). We chose one fiscal year[15] before and after the fiscal year in which the JPO changed its examination policy, that is, the filing date of the sample ran from April 1998 to March 2001.

Next, we prepared the data on entering the EP regional phase by using the existence of EP patent family documents in PATSTAT. The Data on entering the US national phase, however, are not sufficiently made from the existence of the US patent family documents in PATSTAT, as the United States adopted an 18-month early publication system in 1999, which is effective on or after November 29, 2000, and the rejected patent applications filed before then were not published, even if the PCT applications entered the US national phase, Instead, we gathered data on entering the US national phase from the online PATENTSCOPE database provided by the WIPO.

Because the data on the number of claims in PCT applications are lacking from the PATSTAT database, we substituted the number of claims in EP publications entering the EP regional phase for it if applicable: otherwise, we supplemented the deficient data by obtaining the corresponding data using the PATENTSCOPE database.

Finally, we prepared the data on designating EP or US by using the PCT-Bibliographic database provided by the WIPO.

We removed applications claiming no priority as the date on which the ISR is made is ambiguous (within nine months of the filing date). We also removed applications of co-ownership to carry out regressions with the fixed effect of applicants.

3.2. Variables and estimation models

This study uses linear regression models to test the hypotheses, where suffix i stands for the application, suffix j stands for the technology field, suffix k stands for the applicant (assignee), and suffix t stands for the filing date in the calendar month of the application.

In order to test the hypotheses, this article introduce a dummy variable, *policy_change_dummy*, which is set to zero if the filing date is in or before August 1999,

---

[15] The fiscal year of Japan runs from April to March in the following year.

and set to one if the filing date is after August 1999.

To test sub hypothesis H1a, this study uses the following four variables as the dependent variables: i) $ln\_Num\_X\_doc_{i,j,k,t}$, the logarithm of the number of X documents in an ISR; ii) $ln\_Num\_XY\_doc_{i,j,k,t}$, the logarithm of the number of XY documents in an ISR; iii) $ln\_Num\_NPL_{i,j,k,t}$, the logarithm of the number of non-patent literature (NPL) documents in an ISR; and iv) $ln\_Num\_F\_Pat_{i,j,k,t}$, the logarithm of the number of foreign patent documents having no patent families written in Japanese.

As the control variables, this study use the variables that relate to the volume and quality of the inventions in each application and are conventionally used in prior literature (Harhoff et al., 2003; Nagaoka et al., 2010): *ln_Num_claims* (the logarithm of the number of claims in the application) and *ln_Num_inventors* (the logarithm of the number of inventors). In addition, this study use *ln_Num_priority* (the logarithm of the number of applications for which the focal application claims the priority), based on the intuition that the volume of inventions tends to larger for applications claiming more number of prior applications. I expect the dependent variables to be positively correlated with these three control variables.

Further, to control for technology areas, this study uses technology dummies corresponding to the 35 technology areas assigned to each application based on the first IPC subclass classification assigned to each application (Schmoch, 2008). To control for the trend, this study uses dummies for fiscal years, i.e. FY 1998 dummy and FY 2000 dummy, with FY 1999 serving as the baseline as well as interaction terms between the fiscal year dummies and technology dummies. To use the applicant fixed effect model, dummies for applicants are used based on the "DOCDB standard name id" in the PATSTAT database.

The models for testing sub hypothesis H1a, sub-models A1–A4, are as follows (I expect the coefficient for *policy_change_dummy*, β_0, to be positive and statistically significant):

Sub-models A1–A4

$$ln\_Num\_F\_Pat_{i,j,k,t} \text{ (or } ln\_Num\_ln\_NPL_{i,j,k,t},\ ln\_Num\_X\_doc_{i,j,k,t},\ ln\_Num\_XY\_doc_{i,j,k,t})$$
$$= \beta_0\ policy\_change\_dummy$$
$$+\ \beta_1\ ln\_Num\_priority_i + \beta_2\ ln\_Num\_claims_i$$
$$+\ \beta_3 ln\_Num\_inventors_i$$
$$+\beta_j\ tehnology\_dummies\ +\ \beta_t\ fiscal\_year\_dummies$$

$+ \ \beta_{j,t} \ \ tehnology\_dummies \ \ \times \ \ fiscal\_year\_dummies$
$+ \ \beta_k \ \ applicant\_dummies \ \ + constant + \ \ \varepsilon$
(1)

To test sub hypothesis H1b, this study introduces two binary variables as the dependent variables. The first is $US\_enter\_dummy_{it}$, which takes the value of 1 if PCT application *i* filed at *t* entered the US national phase and 0 otherwise. The second one is $EP\_enter\_dummy_{it}$, which takes the value of 1 if PCT application *i* filed at *t* entered the EP regional phase and 0 otherwise. This article uses two linear probability models in which only the dependent variable is different from the other, with the independent variables the same as those used in sub-models A1–A4; hence, the estimation models for testing sub hypothesis H1b, sub-models B1 and B2, are as follows (I expect the coefficient for *policy_change_dummy*, β_0, to be negative and statistically significant and the dependent variables to be positively correlated with the three control variables.):

Sub-models B1 and B2

$US\_enter\_dummy_{i,j,k,t}$ (or $EP\_enter\_dummy_{i,j,k,t}$)
$= \beta_0 \ \ policy\_change\_dummy$
$+ \ \beta_1 \ \ ln\_Num\_priority_i + \beta_2 \ \ ln\_Num\_claims_i$
$+ \ \beta_3 \ \ ln\_Num\_inventors_i$
$+ \ \beta_j \ \ tehnology\_dummies \ \ + \ \ \beta_t \ \ fiscal\_year\_dummies$
$+ \ \beta_{j,t} \ \ tehnology\_dummies \ \ \times \ \ fiscal\_year\_dummies$
$+ \ \beta_k \ \ applicant\_dummies \ \ + constant + \ \ \varepsilon$
(2)

To test hypothesis H1, this study introduces a variable for the quality of the prior art information provided by an ISR prepared for each PCT application i, q_{i}. The independent variables are the same as those used in the sub-models except for $policy\_change\_dummy$; hence, by adopting linear probability modes, the estimation models for testing H1 are expressed as follows, although these contain unobservable variable q_{it}:

Model 1

$US\_enter\_dummy_{it}$ (or $EP\_enter\_dummy_{it}$)
$= \beta_0 \quad q_{\mathrm{i}}$

$$+ \ \beta_1 \ \ ln\_Num\_priority_i + \beta_2 \ \ ln\_Num\_claims_i$$
$$+ \ \beta_3 \ \ ln\_Num\_inventors_i$$
$$+ \ \beta_j \ \ tehnology\_dummies \ + \ \beta_t \ \ fiscal\_year\_dummies$$
$$+ \ \beta_{j,t} \ \ tehnology\_dummies \ \times \ fiscal\_year\_dummies$$
$$+ \ \beta_k \ \ applicant\_dummies \ + constant + \ \varepsilon$$
(3)

This study aims to reveal whether β_0, the coefficient of unobservable variable q_{it}, is negative as well as its absolute value. Since both X documents and Y documents deny novelty or inventive step of filed inventions, this study uses $ln\_Num\_XY\_doc_i$ as a proxy for unobservable variable q_{i}. If Sub hypothesis H1a holds and an increase in $ln\_Num\_XY\_doc_i$ is detected after the policy change, this would justify using this variable as a proxy for q_{it}.

In many cases, combination of two Y documents deny inventive step whereas one X document deny novelty or inventive step of a claimed invention. Hence, one can consider two Y documents are equivalent to one X document. Based on this intuition, this study introduce the following variable as another proxy variable for q_{i}, $ln\_Num\_XhY\_doc_i$, the logarithm of the number of X documents added by the half of the number of Y documents in an ISR.

Since these proxies relates to the number of the examiner's backward citations and they are supposed to be highly endogenous with the value of the patenting overseas of the filed inventions, which is not fully controlled for by the set of control variables, namely $ln\_Num\_priority_i$, $ln\_Num\_claims_i$, and $ln\_Num\_inventors_i$, with dummies for fiscal years, dummies for technology areas, and dummies for applicants. To address this endogeneity, this study uses $policy\_change\_dummy$ as an instrumental variable for the proxies for variable q_{i}. Because the examination policy change was an exogenous shock to applicants, this policy change does not correlate with the value of the patenting overseas of the inventions in the PCT applications immediately after the policy change, nor applicants' ex-post search or ex-post knowledge and possible obsolescence of the invention. In other words, the policy change affected the applicant's decision to enter the national/regional phase only through the changes in the prior art information provided by the ISR produced for the application. That is, the IV used is very likely to satisfy the exclusion restrictions.

4. Results and discussion

4.1. Results of the regression analysis

4.1.1 A marked rise in the number of each kind of documents after August 1999

Table 1 presents a summary results of the regression analyses based on sub-models A1–A4 using the sample that consist of applications that designed US. The regression is carried out for both the sample that designed US and the sample that designated EP, however, the results of the regression analyses on the latter sample is omitted because the results are almost the same. In each regression estimation, applicants are restricted to those that have 5 or more applications in the period. Table 2 presents the descriptive statistics of the data.

The coefficient values for *Policy_change_dummy* are positive and statistically significant at the 1% level for all estimates, controlling for the variables that relate to the volume and quality of the inventions in each application such as the number of applications of which the priority is claimed by the focal application, the number of claims, and the number of inventors with the applicant fixed effect. The results indicate that there was a marked rise after August 1999 in the number of each type of documents, i.e. the number of X documents rose 9.7%, the number of XY documents rose 9.6%, the number of foreign patent documents that have no patent family documents written in Japanese rose 3.4%, and the number of non-patent literature documents rose 5.2% after August 1999. Thus, the unexpected examination policy change by the JPO increased the average number of documents cited in an ISR significantly and dramatically. These results thus support sub hypothesis H1a.

(Table 1 and Table 2 around here)

4.1.2 A significant drop in the rates of entering national/regional phases

Table 3 presents a summary results of the regression analyses based on sub-models B1 and B2. The data used are the same as those used in the previous regression analyses based on sub-models A1–A4. The coefficient values for *Policy_change_dummy* are negative (-0.035 and -0.057) and statistically significant at the 1% level in both estimates, controlling for the trend and variables that relate to the volume and quality of the inventions in the PCT application. These results mean that the number of PCT applications that should have entered the national/regional phase decreased by 3.5% for the US national phase and by 5.7% for the EP regional phase after the examination policy change. These facts support sub hypothesis H1b.

In addition, the coefficient values for such control variables as, $ln\_Num\_priority_{it}$, $ln\_Num\_claims_{it}$,and $ln\_Num\_inventors_{it}$ are all positive and statistically significant, indicating that PCT applications with more volume of inventions and higher quality inventions are more likely to enter the national/regional phase reflecting higher values of patenting overseas. As the JPO's unexpected switch in its patent examination policy caused a drop in the rate of entering the national/regional phase and this policy turnaround, an exogenous shock to applicants, was able to affect them only by improving the quality of the information provided by the ISRs, the policy change made the information provided by an ISR become significantly more useful to the applicant and thus enhanced the screening function of ISRs.

(Table 3 around here)

4.1.3 Results of regression analyses by model 1 using instrumental variable method

Table 4 presents a summary results of the regression analyses by the main model 1, Table 4A on *US_enter_dummy* as the explained variable and Table 4B on *EP_enter_dummy* as the explained variable, respectively. The values of Cragg-Donald Wald F statistic being 13.5 18.5, 12.2, 16.5 in estimation (2), (5), (8), and (11), to show that the variable *PolicyChange_dummy* correlates strongly with the variables *ln_Num_XY* and *ln_Num_XhY*, and *PolicyChange_dummy* seems to be a good instrument. Because the values of Cragg-Donald Wald F statistic is greater for *ln_Num_XhY* than for *ln_Num_XY*, *ln_Num_XhY* is more proper as a proxy for q_{i} than *ln_Num_XY*.

The coefficient values for $ln\_Num\_XY\_doc_i$ and $ln\_Num\_XhY\_doc_i$ are negative and statistically significant at the 5% level in estimate (1) and the 1% level in estimates (4), (7), and (10), respectively. The values are almost same value, -0.37 in estimate (1) and estimate (4), respectively, where the explained variable is *US_enter_dummy*. and -0.60 and -0.61 in estimate (7) and estimate (10), respectively, where the explained variable is *EP_enter_dummy.* The result that the estimated values of the coefficients are almost same seems to also justify the method of this study because IV method will remove the effect of possible random measurement error in q on its estimated coefficient.

The estimated effect of the quality improvement of ISRs on the applicant's decision is large: a 10% increase in quality causes a 4% decrease in entering the US national procedure and a 6% decrease in entering the European regional procedure. These facts support H1.

In addition, the coefficient values for such control variables as, $ln\_Num\_priority_i$, $ln\_Num\_claims_i$, and $ln\_Num\_inventors_i$ are all positive and statistically significant, indicating that PCT applications with more volume of inventions and higher quality inventions are more likely to enter the national/regional phase, reflecting more values of patenting overseas.

Furthermore, the coefficient values for *ln_Num_XY* and *ln_Num_XhY* estimated by using instrumental variable method are an order of magnitude greater than those estimated by using the OLS method (-0.032 and-0.038 for US; -0.037 and – 0.044 for EP), suggesting that the endogeneity with respect to the value obtainable by patenting inventions overseas is very large and not well controlled for by the other control variables; hence, the bias is positive. It is hence very difficult for patent examiners to feel the screening function of their prepared ISRs on the applicants' decision on whether to enter national or regional phases.

Moreover, the regression analyses imply the larger effect of sifting of ISR's for the European regional phase than that for the US national phase, though the difference may not pass a statistical test considering relatively large standard errors of our estimates. The difference might reflect that the standard of the inventive step in the United States was assumed to be lower than that in Europe by applicants in the period (Quillen & Webster, 2006) or that the economic value of patenting an invention in the United States was larger than that in Europe for Japanese applicants.

(Table 4 around here)

4.2. Robustness check

One might consider that the pooled regression analyses explained above may be result from a boom of inventions of the information technology, in which the average rate of the applications entering national/regional phase might be lower than those of the applications in other technologies, e.g. pharmaceuticals. To address this problem, this study implements regression analyses by dividing the sample by technology fields.

Because the size of the sample is not very large, the instrumental variable method will not work well .if the sample is divided into several parts. This study, hence, divides the sample into mainly two parts. Technology fields are often largely divided into two fields, complex and discrete (Cohen, Nelson, and Walsh, 2000). WIPO 35 technology fields are grouped to five larger technology sectors, i.e. "Electrical engineering", "Instruments", "Chemistry", "Mechanical engineering", "Other fields" (Schmoch, 2008). This study regroups these to three groups, i.e. "Complex", "Discrete", and "Others". "Complex" consists of "Electrical engineering", "Instruments", and "Mechanical engineering"; "Discrete" consists of "Chemistry"; and "Others" consists of "Other fields" (see Appendix table A).

The regression analyses are implemented by the same models used in the pooled regression analyses for technology areas of both "Complex" and "Discrete". To increase the sample size, applicants are restricted to those that filed five or more applications in the period in each technology areas.

Table 5 presents a summary results of the regression analyses based on sub-models B1 and B2. The coefficient values for *Policy_change_dummy* are negative (-0.032 and -0.047) and statistically significant at least at the 5% level in both Complex and Discrete technology areas for the US national phase, and are negative (-0.067 and -0.51) and statistically significant at least at the 5% level in both Complex and Discrete technology areas for the EP national phase, controlling for the trend and variables that relate to the volume and quality of the inventions in the PCT application. These facts support H1b.

Table 6 presents a summary results of the regression analyses by the main model 1 by technology areas using instrumental variable method on *US_enter_dummy*. Only *ln_Num_XhY* is used as a proxy for q_i. The values of Cragg-Donald Wald F statistic being 7.6 and 11.0 for “Complex” and “Discrete” in estimation (2) and (4), to show that the variable *PolicyChange_dummy* correlates strongly with the variable *ln_Num_XhY* , and *PolicyChange_dummy* seems to be a good instrument in both samples. The coefficient values for $ln\_Num\_XhY\_doc_i$ are negative (-0.41 for “Complex” and -0.36 for “Discrete”), but statistically significant only at the 10% level in estimates (1) and (3). The decrease of the statistical significance compared to those of pooled regression analyses may come from the decrease of the sample size. Except for this statistical significance decrease, the results are similar to the results of pooled regression analyses.

Estimates (5) to (8) are obtained by implementing the same regression analyses for samples that exclude the applications filed in August, 1999 because ISR’s made for these applications may include those that are made both before and after the examination policy change. The coefficient values for $ln\_Num\_XhY\_doc_i$ are negative (-0.43 for “Complex” and -0.39 for “Discrete”) and statistically significant at the 5% level in estimates (5) and (7) and the values of Cragg-Donald Wald F statistic are 7.6 and 12.1 for “Complex” and “Discrete” in estimates (6) and (8). The results support sub hypothesis H1.

4.3. Discussion

This study revealed that the drastic examination policy change by the Patent Office of the Japanese government markedly increased the number of references cited in an ISR prepared under the PCT system, controlling for such application characteristics as volume and quality, causing a drop in applicants’ decision to enter the national/regional phase. The results suggest that the effect of the 1999 examination policy change was substantive and contributed to the enhancement of the screening function of ISRs.

From the view point of foreign patent authorities, the policy change reduced the duplication of examinations by the USPTO and EPO, contributing to increasing the efficiency of the global patent examination system. Moreover, some of the dropped applications would have been granted by the EPO or USPTO, though these would have been potentially invalid, had there been no improvement in ISRs prepared by the JPO. In addition, improved information on prior art would have helped examiners in the USPTO and EPO narrow the scope of patents that were granted eventually. The 1999 policy change thus would have reduced the social cost that potentially invalid patents might have placed on the domestic and foreign public (Farrell & Shapiro, 2008; Lemley & Shapiro, 2005), thereby benefitting the global public at large.

The average total cost of entering the US and EP procedures for applicants is above one million yen[16] and improving the quality of ISRs enables applicants to save such costly expenditure. More importantly, it would help the applicants to avoid making sunk investment under the premise of non-existing patent protection, which would increase the efficiency of applicants' innovation activities.

As examination speed was still important for the JPO at that time (Ogiya, 2000) and the examination policy change brought about a drop in output as explained in Section 2.3, it seems natural to conclude that no quality improvement would have occurred without a reduction in output and an increase in the average time spent examining one application (e.g., more dedication to prior art search). The present study was unable to assess whether the cost of increasing ISR quality is justified in light of this tradeoff. Further study with more enhanced data would be necessary to tackle the matter and hopefully to refute the conclusions by Cockburn et al. (2002) that providing more time for patent examiners to examine each patent application creates a backlog but subtle change in the quality of patents.

This study used $ln\_Num\_XhY\_doc_i$ and $ln\_Num\_XY\_doc_i$ as proxy variables for q_i, the quality of the prior art information of an ISR, and both of which seems to have worked well. Yet, the former seems better since the values of Cragg-Donald Wald F statistic are greater than those of the other, which seems very natural considering the intuition that one X documents worth a combination of two Y documents.

From the perspective of managing examination process at Patent Offices of the

[16] According to AIPPI JAPAN (2008), the average cost for each PCT applicant is as follows: translation cost, ¥260,000; patent attorney fee, ¥560,000; US national phase entering fee, $1,300; EP entering fee, 1,300 Euro. Personnel expenses for applicants' employees are unknown.

governments in the world, the importance of measuring search quality is well recognized in order to enhance policy making, and promoting international cooperation among patent authorities (Kappos & Graham, 2012; US Government Accountability Office, 2016a, 2016b), however, no established methods have thus far been proposed. This study implies that the number of ISR cited XY documents and the rate of entering the national/regional phase may be potentially valuable indicators for such purposes if they are used with control variables such as the volume and the quality of inventions. It is, hence, desirable for patent authorities globally as well as the WIPO to enhance the relevant data and enable authorities, applicants, and scholars to assess and use such data in a timely and costless manner.

5. Conclusion

This study confirmed that the unexpected drastic examination policy change from quantity-oriented into quality-oriented by the Patent Office of the Japanese government in 1999 increased the quality of ISRs substantially. This exogenous shock brought about a 4% decrease in the US national phase entrance and a 6% decline in the European regional entrance of PCT applications, controlling for the volume and quality of the inventions and the applicant fixed effect as well as technology fields, fiscal year, and interaction terms threreof. By using this exogenous shock, this study revealed that the prior art information provided by an ISR is crucial to the applicant and that improving quality of ISRs affects significantly applicants' decisions to enter the national/regional phase: indeed, a 10% increase in quality causes a 4% decrease in entering the US national procedure and a 6% decrease in entering the European regional procedure. These facts suggest that ISRs provide a valuable screening function and that its enhancement by a national patent office would significantly contribute to applicants' better decisions as well as to raising the efficiency of the global patent examination system.

Importantly, the examination policy change increased search quality at the expense of a drop in examination output. However, the present study was unable to assess whether the cost of increasing ISR quality is justified in light of this tradeoff. Further study with more enhanced data would be necessary to tackle the matter.

Although the importance of measuring search quality is well recognized for such purposes as managing the operations of patent offices, enhancing policy making, and promoting international cooperation among patent authorities, no established methods have thus far been proposed. The number of XY documents cited in an ISR and the rate of entering the national/regional phase may be potentially valuable indicators for such purposes if they are used with control variables such as the volume and the quality of inventions. It is, hence, desirable for patent authorities globally as well as the WIPO to enhance the relevant data and enable authorities, applicants, and scholars to assess and use such data in a timely and costless manner.

Acknowledgements

This work was financially supported by the Japan Science and Technology Agency (JST) under the RISTEX project entitled ‘‘Development of Benchmarks of the Quality of Prior Art Search in International Patent Prosecution Processes.” I would like to thank the JST for granting this aid. I also thank Professor Sadao Nagaoka, Professor Atsushi Ohyama, Professor Kenta Nakamura, Professor Tetsuo Wada, Professor Stuart Graham, and Professor Mark Schankerman for their helpful comments on this work as well as Mr. Yusuke Naito and Ms. Junko Morikawa for their assistance in preparing the data.

References

AIPPI JAPAN, 2008. Study report on the patent law system and its operation in foreign countries toward the realization of the new route proposal. Heisei 19th fiscal year study report on the comparison of the industrial property rights system in foreign countries, Japan. (in Japanese)

Allison, J.R., Lemley, M.A., Moore, K.A., Trunkey, R.D., 2003. Valuable patents. Georgetown Law Journal 92, 435.

Cockburn, I.M., Kortum, S., Stern, S., 2002. Are all patent examiners equal? The impact of examiner characteristics. National Bureau of Economic Research No. w8980.

Cohen, W. M., R. R. Nelson, and J. P. Walsh. 2000. Protecting Their Intellectual Assets: Appropriability Conditions and Why the US Manufacturing Firms Patent (or Not). No. w7552. National Bureau of Economic Research.

De Saint-Georges, M., Van Pottelsberghe de la Potterie, B., 2013. A quality index for patent systems. Research Policy 42(3), 704-19.

Farrell, J., Shapiro, C., 2008. How strong are weak patents? American Economic Review 98(4), 1347-69.

Federal Trade Commission, 2003. To promote innovation: The proper balance of competition and patent law and policy. Federal Trade Commission, United States.

Frakes, Michael D., and Melissa F. Wasserman., 2017. Is the time allocated to review patent applications inducing examiners to grant invalid patents? Evidence from microlevel application data. Review of Economics and Statistics 99(3): 550-563.

Harhoff, D., Scherer, F.M., Vopel, K., 2003. Citations, family size, opposition and the value of patent rights. Research Policy 32(8), 1343-63.

Ishii, T., 2000. New Year's View. Tokugikon 209, 3. (in Japanese)

Jaffe, A.B., Lerner, J., 2004. Innovations and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It. Princeton University Press, Princeton.

Jensen, P.H., Palangkaraya, A., Webster, E., 2005. Disharmony in international patent office decisions. Fed. Cir. Bar J. 15, 679-704.

JPO, 1998. 1998 Annual report, 24. (in Japanese)

JPO, 2011. Study on the examination results of applications through PPH and PCT among the Trilateral Patent Offices: For improvement of patent examination quality. Chizai Kanri 61(9), 1389-1402. (in Japanese)

JPO, 2013. Study on the examination results of applications through PPH and PCT among the Trilateral Patent Offices: For improvement of patent examination quality. AIPPI Journal March 2013, 68-84.

Kappos, D.J., Graham, S., 2012. The case for standard measures of patent quality. MIT Sloan Management Review 53(3), 19.

Keidanren 2000. Keidanren clip, No. 134, 10-11. (in Japanese)

Kim, Yee Kyoung, and Jun Byoung Oh., 2017. Examination workloads, grant decision bias and examination quality of patent office. Research Policy 46, 1005-1019.

Lemley, M.A., 2001. Rational ignorance at the patent office. Northwestern University Law Review 95(4).

Lemley, M.A., Shapiro, C., 2005. Probabilistic patents. The Journal of Economic Perspectives 19(2), 75-98.

Merrill, S.A., Levin, R.C., Myers, M.B., 2004. A Patent System for the 21st Century. National Academies Press, Washington D.C.

Nagaoka, S., Motohashi, K., Goto, A. 2010. Patent statistics as an innovation indicator. In: Handbook of the Economics of Innovation, 2, 1083-1127. North Holland, Oxford

Nagaoka, Sadao, and Isamu Yamauchi., 2017. Information constraint of the patent office and examination quality: Evidence from the effects of initiation lag. RIETI Discussion Paper Series 17-E-040.

Ogiya, T., 2000. Search and examination in quality comparable to that of foreign counterparts. Tokugikon 209, 52-57. (in Japanese)

Quillen, Jr., C.D., Webster, O.H., 2006. Continuing patent applications and performance of the U.S. Patent and Trademark Office. The Federal Circuit Bar Journal 15(4), 635-77.

Sasaki, N., 1998. Toward the realization of the ‘world’s leading patent examination of Japan. Tokugikon 196, 4-5. (in Japanese)

Sasaki, N., 1999. Establishing infrastructure for the 21st century. Tokugikon 203, 4-5. (in Japanese)

Schmoch, U., 2008. Concept of a Technology Classification for Country Comparisons, Final Report to the World Intellectual Property Organisation (WIPO), Geneva, Switzerland. http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf

Tokugikon Study Group on examination quality, 2012. Study on the first actions made by office of second filing for applications under Patent Prosecution Highway

(PPH) system: outcome of the PPH program between Japan and United States. Tokugikon 265, 71-80. (in Japanese)
http://www.tokugikon.jp/gikonshi/265/265kiko.pdf

Trilateral Patent Offices (EPO, JPO and USPTO), 2001. Investigation of use of ISR. Summary of the Trilateral Conference, San Francisco.

Trilateral Patent Offices (EPO, JPO and USPTO), 2002. Investigation of use of ISR. Summary of the 20th Trilateral Conference, Vienna, Austria.

USGAO, 2013. Intellectual property: Assessing factors that affect patent infringement litigation could help improve patent quality. GAO-13-465, Washington D.C., United States.

USGAO, 2016a. Patent Office Should Strengthen Search Capabilities and Better Monitor Examiners' Work. GAO-16-479, Washington D.C., United States.

USGAO, 2016b. Patent Office Should Define Quality, Reassess Incentives, and Improve Clarity. GAO-16-490, Washington D.C., United States.

Wada, T., 2014. Analysis of the technology sectoral distribution of major countries' patent documents and the efficiency of prior art search. Heisei 25th fiscal year study report on the application behavior of industrial property rights toward acceleration of innovation in Japan. (in Japanese)

Wada, T., 2016. Obstacles to prior art searching by the trilateral patent offices: Empirical evidence from International Search Reports. Scientometrics 107(2), 701-22.

Webster, E., Palangkaraya, A., Jensen, P.H., 2007. Characteristics of international patent application outcomes. Economics Letters 95(3), 362-68.

WIPO 2020. China Becomes Top Filer of International Patents in 2019 Amid Robust Growth for WIPO's IP Services, Treaties and Finances. PR/2020/848.
https://www.wipo.int/pressroom/en/articles/2020/article_0005.html

WIPO 2015a. Patent Cooperation Treaty Yearly Review, Geneva, Switzerland.
http://www.wipo.int/edocs/pubdocs/en/wipo_pub_901_2016.pdf

WIPO 2015b. PCT International Search and Preliminary Examination Guidelines, Geneva, Switzerland.
http://www.wipo.int/export/sites/www/pct/en/texts/pdf/ispe.pdf.

Yamauchi, Isamu, and Sadao Nagaoka., 2015. Does the outsourcing of prior art search increase the efficiency of patent examination? Evidence from Japan. Research Policy 44, 1601-1614.

Fig. 1 Average number of ISR-citing documents by filing date

Fig. 1A

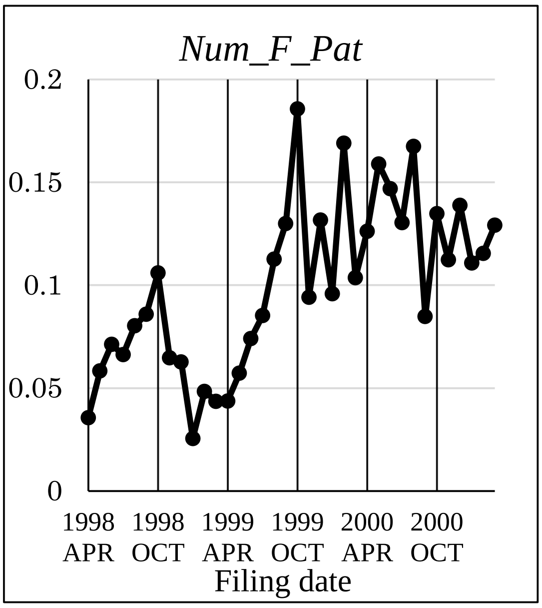


Fig. 1B

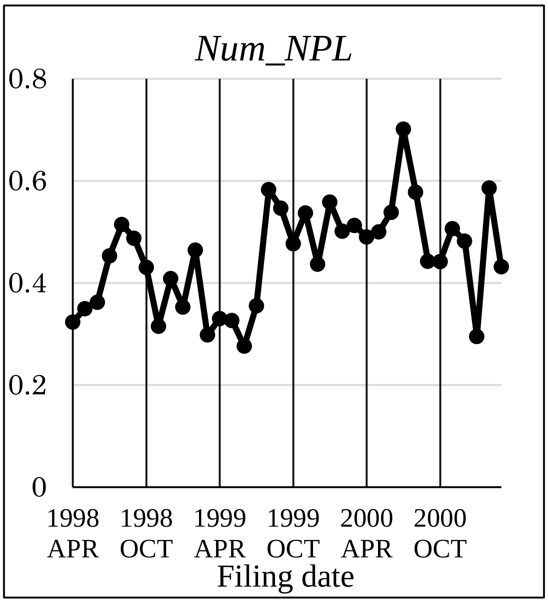


Fig. 1C

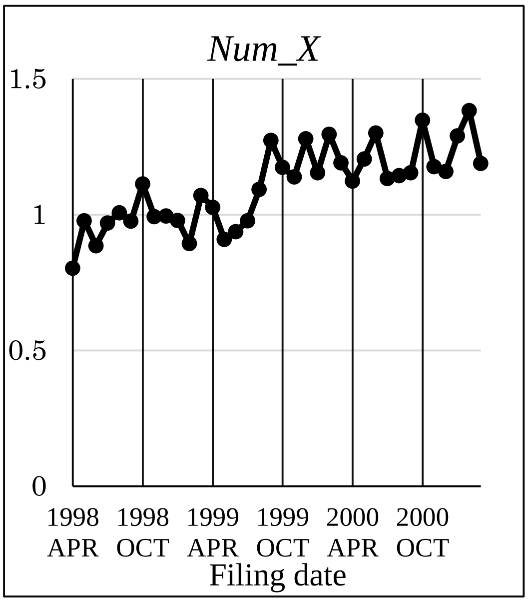
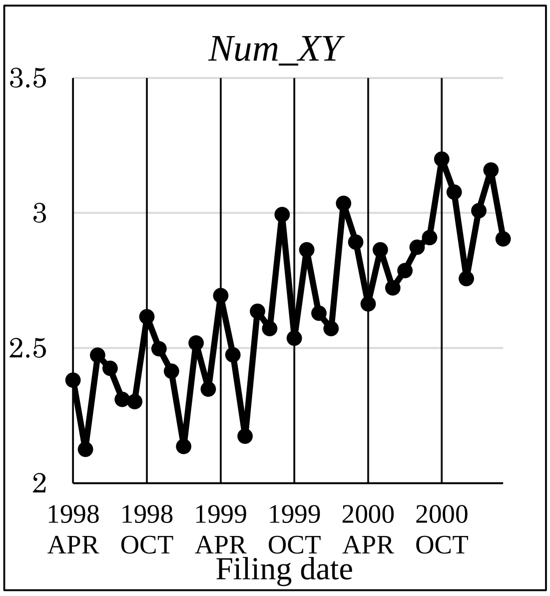


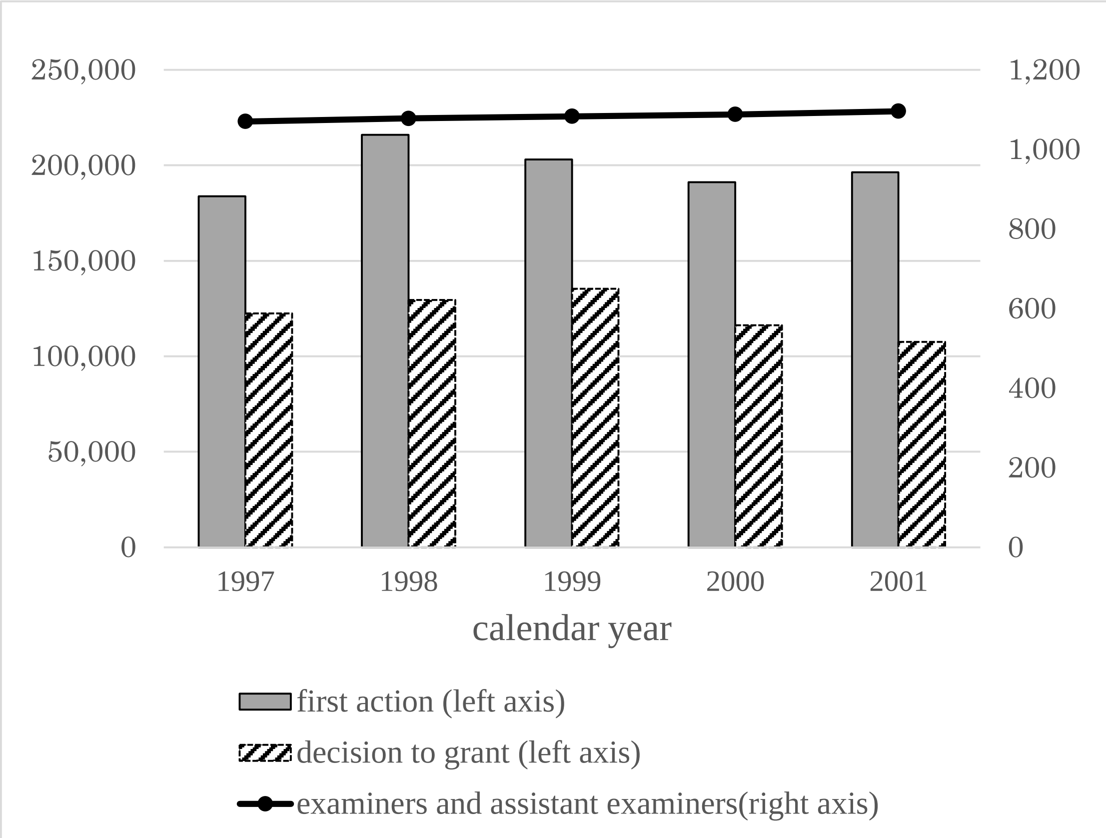
Fig. 1D



Data source: Constructed by the author from PATSTAT database (2015 autumn version), PATENTSCOPE database, and PCT-Bibliographic database.

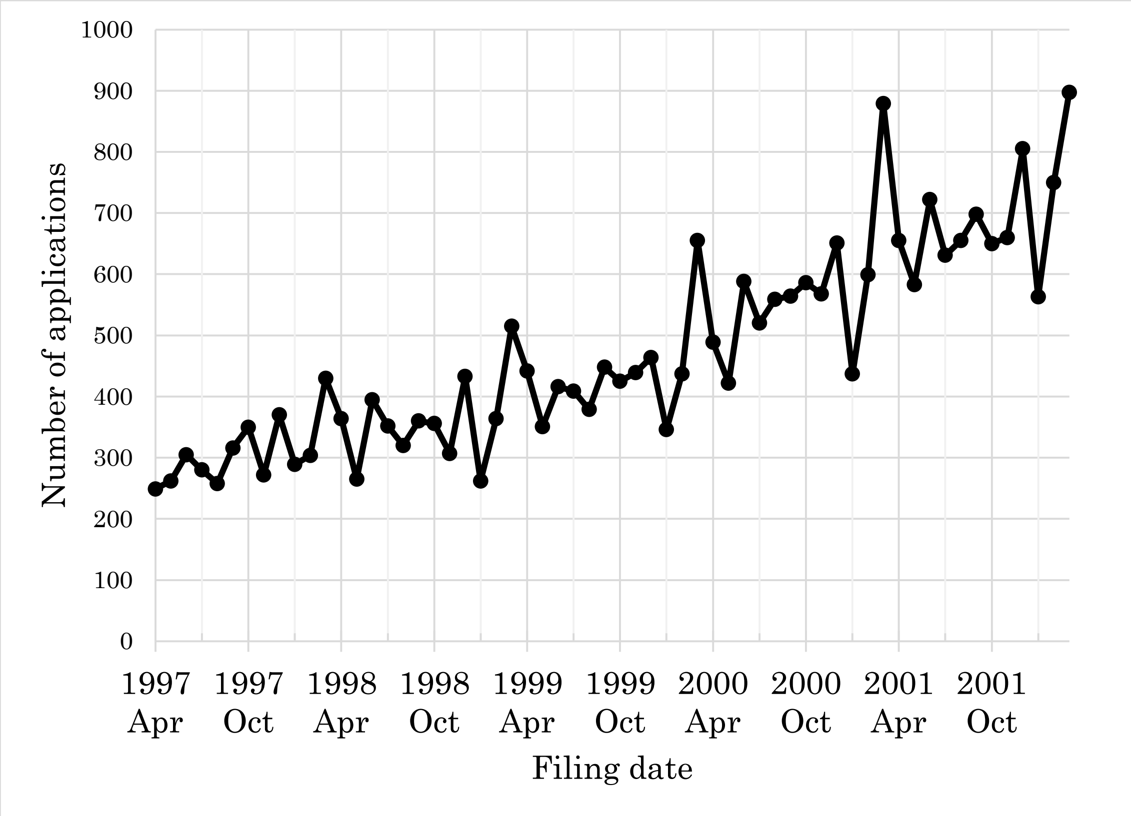
Note: 1A: Foreign patent documents having no Japanese language families, 1B: Non-patent literature, 1C: X documents, 1D: XY documents. Applications are restricted to those that designated the United States as the designated country. Applications of co-ownership (two or more assignees) or claiming no priority are removed. Assignees are restricted to those that have six or more applications in the period from FY1998 to FY2000.

Fig. 2. Change in the number of examiners, first actions, and grant decisions



Data Source: Annual report of each year by the Japan Patent Office

Fig. 3 Trend of PCT applications



Data source: Constructed by the author from PATSTAT database (2015 autumn version) and PCT-Bibliographic database.

Note: Applications are restricted to applications that designated the United States as one of the designated countries. Applications of co-ownership (two or more assignees) and claiming no priority are removed. Assignees are restricted to those that have six or more applications in the period from FY1998 to FY2000.

Fig. 4 Rate of entering the national/regional phase procedure

Fig. 4A US national phase

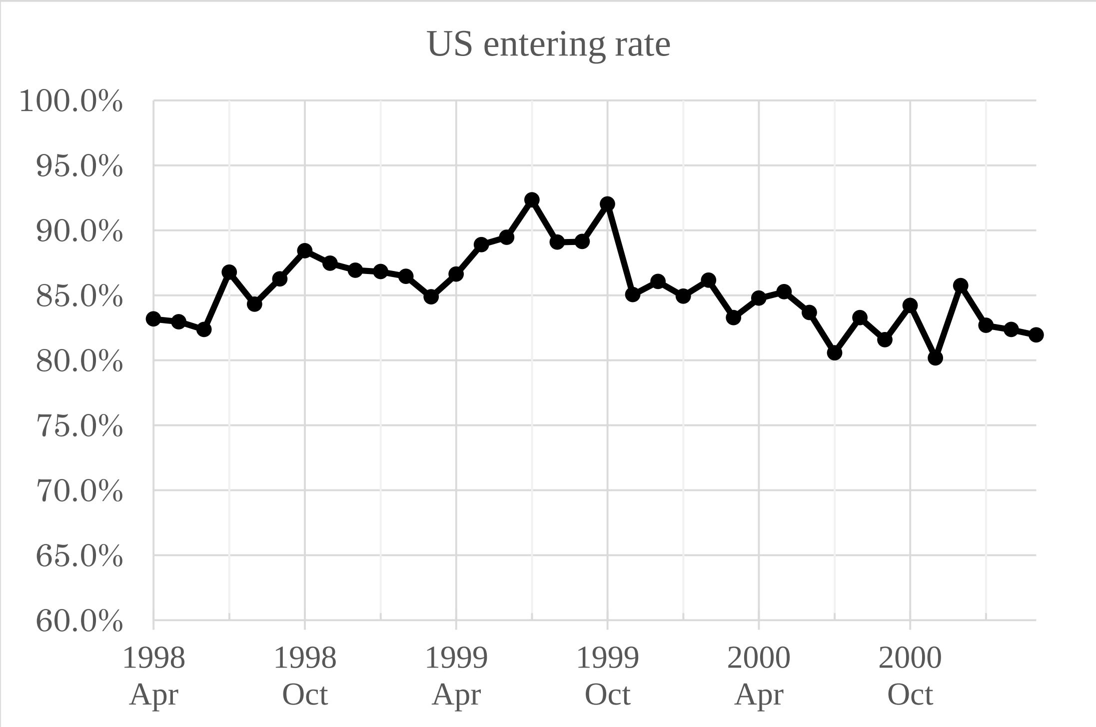
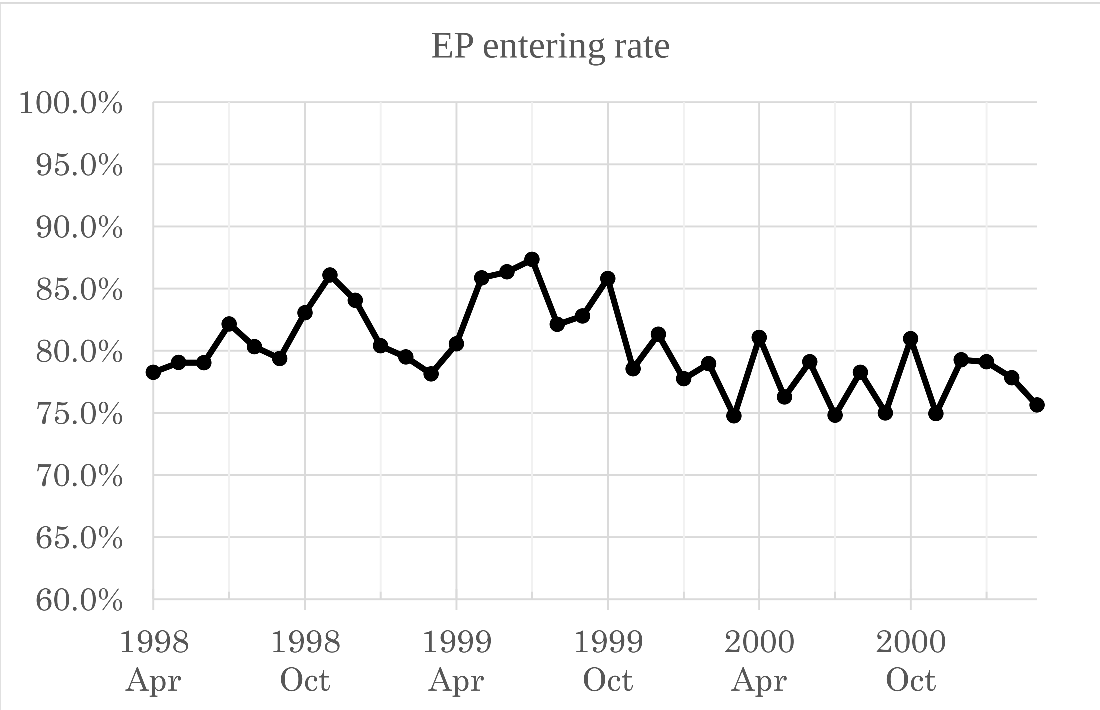


Fig. 4A EP regional phase



Data source: Constructed by the author from PATSTAT database (2015 autumn version), PATENTSCOPE database, and PCT-Bibliographic database.

Table 1 Policy change effect on the number of documents cited in ISRs

	(1)	(2)	(3)	(4)
Explained variables	*ln_Num_X*	*ln_Num_XY*	*ln_Num_F_Pat*	*ln_Num_NPL*
PolicyChange_dummy	.0967***	.0957***	.0335***	.0519***
	(.0215)	(.0236)	(.00742)	(.0134)
ln_Num_priority	.0873***	.111***	.00840	.0129
	(.0143)	(.0172)	(.00547)	(.00942)
ln_Num_claims	.100***	.147***	.00553*	.0338***
	(.00935)	(.0149)	(.00282)	(.00802)
ln_Num_inventors	.0305***	.0413***	.00423	-.00525
	(.00918)	(.0142)	(.00328)	(.00767)
fiscal year	yes	yes	yes	yes
tech35	yes	yes	yes	yes
fiscal year tech35	yes	yes	yes	yes
applicant	FE	FE	FE	FE
Observations	13,523	13,523	13,523	13,523
R-squared	.0510	.0562	.0288	.131
Number of applicants	395	395	395	395
adjusted R-Squared	0.0434	0.0486	0.0210	0.124
Log Likelihood	-12289	-15402	1684	-5995

Note: 1. Robust standard errors in parentheses.

2. *** p<0.01, ** p<0.05, * p<0.10.

3. Samples are those that designated the United States as a designated country and that claims priority based on earlier patent application and that filed six or more applications in fiscal 1998 - 2000.

Table 2 Descriptive statistics for the data used in the regression analysis

2A PCT patent applications that designated the United States

N=13,523

	mean	sd	p50	min	max
US_enter_dummy	0.85	0.36	1	0	1
Policy_change_dummy	0.63	0.48	1	0	1
ln_Num_X_doc	0.50	0.64	0	0	4.16
ln_Num_XY_doc	0.99	0.81	1.10	0	4.16
ln_Num_XhY_doc	0.82	0.69	0.92	0	4.16
ln_Num_NPL	0.20	0.48	0	0	3.50
ln_Num_F_Pat	0.06	0.23	0	0	2.40
ln_Num_priority	0.29	0.49	0	0	3.14
ln_Num_claims	2.48	0.78	2.48	0	5.98
ln_Num_inventors	1.00	0.62	1.10	0	3.09

2B PCT patent applications that designated European patents

N = 12,480	mean	sd	p50	min	max
EP_enter_dummy	0.80	0.40	1	0	1
Policy_change_dummy	0.63	0.48	1	0	1
ln_Num_X_doc	0.50	0.64	0	0	4.16
ln_Num_XY_doc	0.99	0.81	1.10	0	4.16
ln_Num_XhY_doc	0.82	0.69	0.92	0	4.16
ln_Num_NPL	0.21	0.49	0	0	3.50
ln_Num_F_Pat	0.07	0.23	0	0	2.40
ln_Num_priority	0.30	0.50	0	0	3.14
ln_Num_claims	2.48	0.78	2.48	0	5.98
ln_Num_inventors	1.02	0.62	1.10	0	3.09

Table 3 Policy change effect of entering the US national phase or EP regional phase

	Explained Variables	
	(1)	(2)
	US_enter_dummy	*EP_enter_dummy*
Explanatory Variables		
PolicyChange_dummy	-.0352***	-.0567***
	(.0107)	(.0131)
ln_Num_priority	.0236***	.0248***
	(.00702)	(.00919)
ln_Num_claims	.0263***	.0301***
	(.00596)	(.00692)
ln_Num_inventors	.0158**	.0266***
	(.00623)	(.00767)
fiscal year dummies	yes	yes
tech35_dummies	yes	yes
*fiscal_dummies * tech35_dummies*	yes	yes
applicant	FE	FE
Observations	13,523	12,480
R-squared	.0281	.0293
Number of applicants	395	384

Note: 1. Robust standard errors in parentheses.

2. *** p<0.01, ** p<0.05, * p<0.10.

Table 4 The summary results of the regression analyses by the main model 1 using Instrumental variable method

Table 4A Analyses on *US_enter_dummy*

	Explained variable: *US_enter_dummy*					
Explanatory variables	(1) IV second stage	(2) first stage	(3) OLS	(4) IV second stage	(5) first stage	(6) OLS
ln_Num_XhY				-.370***		-.0377***
				(-2.68)		(-8.66)
ln_Num_XY	-.368**		-.0316***			
	(-2.52)		(-8.55)			
PolicyChange_dummy		.0957***			.0952***	
		(3.68)			(4.31)	
ln_Num_priority	.0645***	.111***	.0275***	.0621***	.104***	.0279***
	(3.51)	(6.75)	(3.95)	(3.76)	(7.44)	(4.00)
ln_Num_claims	.0804***	.147***	.0308***	.0758***	.134***	.0312***
	(3.60)	(13.7)	(6.73)	(3.92)	(14.6)	(6.81)
ln_Num_inventors	.0310***	.0413***	.0174***	.0300***	.0383***	.0175***
	(3.41)	(3.22)	(3.21)	(3.61)	(3.52)	(3.23)
tech35_dummies	yes	yes	yes	yes	yes	yes
fiscal year	yes	yes	yes	yes	yes	yes
*fiscal*tech35*	yes	yes	yes	yes	yes	yes
applicant	FE	FE	FE	FE	FE	FE
Observations	13,523	13,523	13,523	13,523	13,523	13,523
R-squared	-.583	.0562	.0328	-.401	.0600	.0329
Number of applicants	395	395	395	395	395	395
C-D W F statistic		13.54			18.54	

Note: 1. Z-statistics or t-statistics in parentheses.
2. *** p<0.01, ** p<0.05, * p<0.10.

Table 4B Analyses on *EP_enter_dummy*

	Explained variable: *EP_enter_dummy*					
	(7)	(8)	(9)	(10)	(11)	(12)
	IV		OLS	IV		OLS
Explanatory variables	second stage	first stage		second stage	first stage	
ln_Num_XhY				-.606***		-.0438***
				(-3.13)		(-8.67)
ln_Num_XY	-.599***		-.0368***			
	(-2.87)		(-8.56)			
PolicyChange_dummy		.0947***			.0936***	
		(3.49)			(4.06)	
ln_Num_priority	.0934***	.115***	.0294***	.0901***	.108***	.0299***
	(3.48)	(6.76)	(3.68)	(3.81)	(7.48)	(3.74)
ln_Num_claims	.120***	.150***	.0352***	.113***	.136***	.0357***
	(3.68)	(13.3)	(6.58)	(4.09)	(14.2)	(6.66)
ln_Num_inventors	.0423***	.0262*	.0278***	.0433***	.0277**	.0281***
	(3.76)	(1.94)	(4.36)	(4.14)	(2.40)	(4.40)
tech35_dummies	yes	yes	yes	yes	yes	yes
fiscal year	yes	yes	yes	yes	yes	yes
*fiscal*tech35*	yes	yes	yes	yes	yes	yes
applicant	FE	FE	FE	FE	FE	FE
Observations	12,480	12,480	12,480	12,480	12,480	12,480
R-squared	-1.34	.0572	.0336	-.963	.0611	.0338
Number of applicants	384	384	384	384	384	384
C-D W F statistic		12.21			16.48	

Note: 1. Z-statistics or t-statistics in parentheses.

2. *** p<0.01, ** p<0.05, * p<0.10.

Table 5 A summary results of the regression analyses based on sub-models B1 and B2 by technology areas

Explained variables	*US_enter_dummy*		*EP_enter_dummy*	
	(1)	(2)	(3)	(4)
	Complex	Discrete	Complex	Discrete
PolicyChange_dummy	-.0320**	-.0468***	-.0672***	-.0505**
	(.0131)	(.0178)	(.0177)	(.0214)
ln_Num_priority	.0288***	.0188	.0330***	.0190
	(.00832)	(.0136)	(.0122)	(.0154)
ln_Num_claims	.0131***	.0518***	.0124*	.0597***
	(.00494)	(.0105)	(.00672)	(.0117)
ln_Num_inventors	.0120*	.0175	.0282***	.0185
	(.00684)	(.0126)	(.00918)	(.0142)
fiscal year	yes	yes	yes	yes
tech35	yes	yes	yes	yes
fiscal year tech35	yes	yes	yes	yes
applicant	FE	FE	FE	FE
Observations	8,063	5,201	7,194	5,004
R-squared	.0343	.0271	.0394	.0242
Number of applicants	264	243	250	231
adjusted R-Squared	0.0252	0.0205	0.0293	0.0173
Log Likelihood	-1272	-2080	-2333	-2216

Note: 1. Robust standard errors in parentheses.

2. *** p<0.01, ** p<0.05, * p<0.10.

Table 6 A summary results of the regression analyses based on model 1 by technology areas using instrumental variable method

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Explained variable: *US_enter_dummy*							
VARIABLES	Complex 2nd stage	Complex 1st stage	Discrete 2nd stage	Discrete 1st stage	Complex 2nd stage *#1*	Complex 1st stage *#1*	Discrete 2nd stage *#1*	Discrete 1st stage *#1*
ln_Num_XhY	-.412*		-.356*		-.427**		-.388**	
	(-1.95)		(-1.89)		(-1.99)		(-2.08)	
PolicyChange_dummy		.0762***		.130***		.0776***		.138***
		(2.76)		(3.32)		(2.76)		(3.47)
ln_Num_priority	.0699***	.104***	.0564**	.104***	.0715***	.107***	.0604**	.107***
	(2.91)	(5.89)	(2.26)	(4.24)	(2.87)	(6.00)	(2.35)	(4.33)
ln_Num_claims	.0669**	.131***	.104***	.147***	.0689**	.129***	.109***	.147***
	(2.36)	(11.7)	(3.45)	(8.77)	(2.42)	(11.4)	(3.63)	(8.67)
ln_Num_inventors	.0353**	.0548***	.0207	.00789	.0365**	.0566***	.0185	.00236
	(2.56)	(4.23)	(1.54)	(.37)	(2.54)	(4.34)	(1.32)	(.109)
Observations	7,853	7,853	5,016	5,016	7,699	7,699	4,882	4,882
R-squared	-.545	.0711	-.358	.0502	-.588	.0714	-.439	.051
Number of applicants	222	222	206	206	222	222	206	206
C-D W F statistic	7.63		11.03		7.63		12.05	

Note: 1. Z-statistics or t-statistics in parentheses.

2. *** p<0.01, ** p<0.05, * p<0.10.

3. Analyses (5) to (6) marked with "#1" are implemented with samples that exclude applications filed in August, 1999.

Appendix Table A. Technical fields

C or D	Technology sector	Technology field
Complex	Electrical engineering	1 Electrical machinery, apparatus, energy, 2 Audio–visual technology, 3 Telecommunications, 4 Digital communication, 5 Basic communication processes, 6 Computer technology, 7 IT methods for management, 8 Semiconductors
Complex	Instruments	9. Optics, 10 Measurement, 11 Analysis of biological materials, 12. Control, 13. Medical technology
Discrete	Chemistry	14 Organic fine chemistry, 15 Biotechnology, 16 Pharmaceuticals, 17 Macromolecular chemistry, polymers, 18 Food chemistry, 19 Basic materials chemistry, 20 Materials, metallurgy, 21 Surface technology, coating,, 22 Micro–structural and nano–technology, 23 Chemical engineering, 24 Environmental technology
Complex	Mechanical engineering	25 Handling, 26 Machine tools, 27 Engines, pumps, turbines, 28 Textile and paper machines, 29 Other special machines, 30 Thermal processes and apparatus, 31 Mechanical elements, 32 Transport
Others	Other fields	33 Furniture, games, 34 Other consumer goods, 35 Civil engineering