A survival analysis of patent examination request in Japanese electrical and electronic manufacturers

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Abstract

In this paper, we seek to identify the major determinants of the length of period between filing and examination request for Japanese patent. We consider three factors that may influence request, i.e., value index options for patent, strategy of patent filing and innovation, and environment changes faced by Japanese companies. Our sample covers over 214 listed companies in Japanese electrical and electronic manufacturing sector, and their patent applications between 1988 and 2001. The empirical results showed that, in the early 1990s, large scale firms and firms with high R&D intensity and patent propensity had a tendency to delay their request activity. But during the late 1990s, they turn to accelerate the request activity. Addition to the number of claims, some other indexes of the value of patents, i.e., originality, forward self-citation and external citation are positively related to early examination request through the most periods of our sample. And joint-application and generality show somewhat mixed effects on the request activity. Furthermore, our results revealed that including time-varying factors gave different results for the effect of the term related to competition filing.

Key Words: survival analysis, patent examination request, Japanese electrical and electronic manufacturers

JEL Classification: C41, O31, O34

1 Introduction

According to Japanese Patent Law, Japanese Patent Office (hereafter JPO) examiner will not investigate patent application until the patent applicants request for examination and pay examination fee. The examination can be requested by the applicants

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themselves, as well as by a third party. JPO patent applicants have seven years from the filing date to decide whether or not to request an examination by the JPO's examiner. Since Oct. 1, 2001, this examination request time has been shortened to three years due to the amendment of Japanese Patent Law in 2001[1]. Under this system, if no request for examination is made within this request time (7 years for filing before Oct. 1. 2001, and 3 years after then), the patent application is deemed to have been withdrawn (See Figure 1).

The examination request system was introduced in Japan in 1971 (Okada and Asaba (1996)), and has been widely used in some other Asian patent institutes such as 3 year request time in China and Taiwan, and 5 year in Korea, although there is no third party request in China[2].

Due to the fact that most of applicants do not request for examination until the examination request time is close to end, many studies have focused on the reason why some do their request activities earlier and some do not. In order to investigate the major cause of length of the period between filing and requesting for examining for Japanese patent, some empirical literature has tried to identify the role of value of patent application and examine correlation between the (objective) value of the application and the length of period preceding the request for examination.

Nakamura and Odagiri (2007), in their analysis for Japanese biotechnology related patent, found that number of patent claims and application of foreign patent for the same invention filed in JPO had the effect of shortening the length of period between filing and examination request. Using both theoretical model and empirical analysis, Nagaoka et al. (2007) and Yamaguchi and Nagaoka (2008) examined the effects of reforms in Japanese patent system on rate of examination request. These reforms includes introduction of multiple claim system in 1988, shortening the examination request time in 2001 and revision of examination request fee in 2004. Their results showed that the increase in the average number of claims increases the value of applications and raises the rate of examination request. They also argued that the shorter period of examination request is associated with increasing the request rate of low-quality application, whereas higher examination request fee is in favor of the request rate of high-quality application.

On the other hand, to explore the reason for delaying request activity, literature focused on "provisional" protection on European patents may be suggestive.

Zeebroeck (2007), in his analysis in European patent, described two lives which include decision lag between filing and request for examination, and active life between grant and lapse. A European patent application, as soon as it has been published, produces the same legal effects and provides the same protection as if it were granted. If a patent filing remains pending for years before it ultimately gets refused, the applicant will have benefited from a very long but very questionable legal protection. Therefore, the duration of the granting process of patent applications matters as much.

The hypothesis of discretionary duration may also be useful to explain what happens in the case of examination request in Japan. That Japanese patent applicants delay their request for examination may be due to this kind of "provisional" protection provided to the patent applications. Therefore, the length of period between filing and

[1]This kind of request time is about two years for patents in European Patent Office, while there is no such system in the U.S. Patent and Trade Mark Office.

[2]See "http:www.sipo.gov.cnsipo_English", "http:www.tipo.gov.twenindex.aspx" and "http:www.kipo.go.kren" for the examination request systems in China, Taiwan and Korea.

request for examination would be associated with patenting behavior or strategy of Japanese companies in a case of seeking a legitimate provisional protection, even their patent applications could not be granted at last.

Although Japanese companies have been ahead in the number of patent applications submitted so far, Japan was truly a "filing great power" rather than "real-life patent power" (Arai(1999)). In other words, Japanese lag behind the United States and European Community in terms of holding patents, and this has been a major reason Japanese companies have frequently paid settlements and damages stemming from patent disputes such as TI's lawsuit to Japanese semiconductor manufacturers in 1986[3]. As indicated by Arai(1999), the examination request system in Japan may be one of the reasons of patent holding lag.

In this paper, rather than focusing on the effects of reforms in Japanese patent system as analyzed in Nagaoka et al. (2007) and Yamaguchi and Nagaoka (2008), we attempt to examine the relationship between Japanese company's strategies of innovation and patent filing and the length of period between filing and examination request. We pay attention to what changed in the innovation and patenting strategy between 1988-2001, and how the changes effected the request activity. We also consider other factors, i.e., index options for patent values and time-varying factors in request decision.

Our sample covers 214 Japanese electrical and electronic companies, which made approximately 1,530,000 applications between Jan. 1, 1988 and Sept. 30, 2001. The empirical results showed that, in the early 1990s, large scale firms and firms with high R&D intensity and patent propensity had a tendency to delay their request activity. But during the late 1990s, they turn to accelerate the request activity. Addition to the number of claims, some indexes of the value of patents, i.e., originality, forward self-citation and external citation are positively related to early examination request through the most periods of our sample. And joint-application and generality show somewhat mixed effects on the request activity. Furthermore, our results reported that including time-varying factors gives different results for the effect of the term related to competition filing. Based on a survival analysis of examination request, our findings firstly revealed that the changes occurred in innovation and IP strategy in Japanese electrical and electronic firms did influence their patent filing behavior between 1988 and 2001.

The paper is organized as follow. Section 2 examines evidence on length of period between filing and examination request in Japanese electrical and electronic manufacturers. Section 3 introduces econometric methodology used in our empirical analysis, and discusses some potential explanatory factors which may determine the length of period. In Section 4 we provide empirical results. And Section 5 concludes.

[3]In 1986, TI, which holds numerous basic patents in the field of semiconductors, brought a lawsuit against 9 Japanese and Korean semiconductor companies for infringing upon its basic DRAM patent. The suit was settled out of court. TI is said to have received more than $200 million in royalties at that time. (see Afuah(1999))

2 Evidence from Japanese electrical and Electronic Manufacturers

To examine evidence on length of period between filing and examination request, we use data taken from the dataset released by the Institute of Intellectual Property (IIP), which includes date of application, examination request, registration (grant) and lapse of JPO patents, and citations from 1960s to 2008. To explore if there is any change in behavior of examination request in Japanese companies, we use data of the patents which filed applications between 1988 and Dec. 30, 2001. Although the amendment of examination request time was implemented in Oct. 1, 2001, application filed before that date still had 7 years to decide whether to request or not.

Figure 2 shows histograms of the months between filing of application and examination request in JPO in some selected application years, i.e., 1988, 1993 and 1999. We find that, for the applications applied in 1988, the date of request are concentrated in late period of the 7 years (or 84 months), most of them happened just before the deadline day of examination request time. That means that many applicants make full use of the examination request time by delaying their request activity. For the applications applied in 1999, however, the request activity seems to be accelerated.

Figure 3 presents the Kaplan-Meier estimate based on the application year respectively. Analysis time is the months from application filing to examination request. We also show the Nelson-Aalen estimate of the survival functions in Figure 4. The figures reveal some characteristics of Japanese companies in examination request. The first is that for all application years, more than 80 percent of the examination requests happened beyond 20 months after filing. The probability of the request happened before the publication of application (18th month after filing) is very limited. Secondly, compared with those filed between 1988 and 1992, those filed between 1999 and 2001 preceded their examination request activity two years or more. Thirdly, the examination request ratio, i.e., the share of number of applications requested to total applications, seemed to have increased gradually from 42% to 56%, especially after 1993.

We utilize log-rank test for trend to investigate if there are differences and trend in the survival function across the three periods, i.e., 1988-1992, 1993-1998 and 1999-2001. The test result is presented in Table 1. Our test confirms that the survival functions of three subsamples are significantly different from each other and there is a trend existed.

Thus, we may divide our sample into three subsamples. The first subsample includes the applications applied for between 1988 and 1992, the second is between 1993 and 1998, and the third is between 1999 and 2001. We suppose that, since the behavior of examination request between three periods is different, and effects of determinants on the behavior of request would be different as well.

3 Framework for Survival Analysis

3.1 Model Specification

In order to analyze the determinants of the length of period between filing and examination request in Japanese companies, we consider to use a survival analysis technique here. We define the length of period between filing and request as a survival time, which is a nonnegative random variable T with a given cumulative distribution $F(t)$ and probability density function $f(t)$. In our survival analysis, $F(t)$ is frequently denoted as the failure function $F(t) = P(T \leq t)$, that is the probability that the patent examination was requested before or at time t. The survival function, denoted as $S(t)$ where t is the days between the date of filing of examination request and patent application, can be computed as $S(t) = P(T > t) = 1 - F(t)$. Thus, it follows that,

$$f(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T \leq t + \Delta t)}{\Delta t} = \frac{\partial F(t)}{\partial t} = -\frac{\partial S(t)}{\partial t} \tag{1}$$

The hazard function $\lambda(t)$ can then be defined as,

$$\begin{aligned} \lambda(t) &= \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \\ &= \lim_{\Delta t \to 0} \frac{F(t + \Delta t) - F(t)}{\Delta t S(t)} \\ &= \frac{f(t)}{S(t)} = -\frac{d \ln S(t)}{dt} \end{aligned} \tag{2}$$

In the duration analysis literature, hazard function depends on a set of covariates $x' = (x_1, \cdots, x_K)$ that influence the survival time T. As a semi-parametric specification, Cox Proportional Hazard model proposed by Cox (1972). The relative hazard between two observations is assumed to be independent of the baseline hazard and the Cox estimation can be performed without any other functional restrictions. In some cases such as no overlaps in observations, however, the Cox regression ignores some information which can be exploited by a parametric model. In following empirical analysis, we utilize Weibull regression to investigate the determinants of the length period of examination request, and we also use the Cox regression to reconfirm our results obtained from Weibull regression. At the same time, we also attempt to use a mixture regression technique discussed in Lambert et al. (2005), Lambert et al. (2007) and Lambert (2007) to estimate the request time and request ratio simultaneously.

3.2 Potential Explanatory Factors

As mentioned in the introduction, a European patent application, as soon as it has been published, produces the same legal effects and provides the same protection as if it were granted. This kind of "provisional" protection has a counterpart in JPO patent system. Under Article 64 of Japanese Patent Law, a Japanese patent application will be published no later than 18 months after filing of application. As effect of the laying open of applications, Article 56 states that, "after ... open of a patent application, ..., the applicant may claim compensation against a person who has worked the invention as a business after the warning (by the applicant) and prior to the registration establishing a patent right, ... Even where the said warning has not been given, the same shall

apply to a person who knowingly commercially worked an invention claimed in a laid open patent application, prior to the registration establishing a patent right. " The implication of Article 65 means that if it has been published, a JPO patent application may be provided a kind of legal effects even before examination or grant. Those effects of the legal rights or protection are similar to those provided to a granted patent, although they are provisional and "the right to claim compensation ... may not be exercised until the registration establishing a patent right has been effected." Therefore, the applicants may have sufficient time to produce legal effects by delaying their request, and use these legal effects to threaten his competitors, granting him a non-negligible bargaining power (van Zeebroeck, p. 5). How long a patent application remains pending before request may then link to experience, capability or strategy in innovation and patenting, which may be proxied by firms scale, R&D intensity and patent propensity and so on. Then, these consideration lead to the following hypothese,

Hypothesis I. The companies with more experience and capability in innovation or IPR are more likely to delay their request activities to pursue the "provisional" protection, since about 50% of patent applications has been not granted at last.

Due to some happenings of IPR, i.e., a series of patent lawsuits between the US and Japanese semiconductor companies happened in the late of 1980s, some changes occurred implicitly in innovation and IP strategy in Japanese electrical and electronic firms. The patent strategies changed to the direction of competing for quality more so than quantity. In the mid and late 1990s, some companies introduced new system in evaluation and reward to their inventors one after another[4]. From our interview with an engineer in Panasonic Inc., these changes can be summarized as follows.

	Purpose of patenting	Quota	Evaluation
Before change	Quantity	Impotent	Quota achievement
After change	Quantity + high quality	Less impotent	Minimum quota achievement + license and cross license

Consequently, our second hypothesis is,

Hypothesis II. Changes of innovation and IPR environment and strategy in the late of 1990s may lead earlier request activities, especially for the companies with high R&D intensity and patent propensity.

In their analysis on U.S. semiconductor companies, Hall and Ziedonis (2001) indicated that, the firms' purpose of building their large portfolios of patents were to be used as "bargaining chip" and to improve their competitive position vis-a-vis direct market rivals as well. To compete with rivals, holding more patents should be impotent. That firms applied for more patents may be due to their active strategy of patent portfolio, and also be just a defense reaction in response to that the rivals had applied for much patents in same technology field. Therefore, competition filing activities may influence the behavior of examination request. On the other hand, during the period

[4]See Nikkei Telcom Database for the development of evaluation and reward systems in Japanese top electrical and electronic companies in the late of 1990s.

between filing and request, rival's actions may vary over time. Thus, decision on when to request, and whether or not to request may not be finished in the day of filing, and need to be continued in whole period between filing and request. These consideration then lead the hypothesis as,

Hypothesis III. Competition filing may influence the length of period of examination request, and time varying factors should be considered.

Some literature focused on correlation between the values of patents and the behavior of patent examination request in Japanese firms. Nagaoka et al. (2007), in their comparative static analysis, argued that, increase in the number of patent claims, a proxy of the value of the patent, will lead to a higher rate of examination requests. Furthermore, the increase of patent claims has a positive effect on the early request activity for the firms that face with high level of uncertainty in patent value. Nakamura and Odagiri (2007) also concluded that the higher the patent value as well as the degree of certainty of the patent value, the earlier and examination request tends to be filed. They used number of application of foreign patent for the same invention, number of patent claims and number of citations the patent received as the proxy indexes of the patent value to investigate if there exists a correlation between the patent value and the behavior of examination request. Based on a survival analysis technique, their findings show that these patent value indexes have significant effects of preceding the examination request in biotechnology-related patent applications.

Patent citations received may indicate that the cited patent has an extra value above the average, because the valuable patents may be cited more often than other patents. As pointed out by Maurseth (2005), however, when a patent occurs that renders an existing patent obsolete, it also seems likely that is will trigger a patent citation. Some patent citations are self–citations that a patent receives citations by patents applied for either by the same inventor who developed the original patent or by the same firm that applied for the original patent. Maurseth (2005) discussed the difference in the nature between self–citations and external citations in the sense of value of patent, and found that the former has no significant impact on patent renewal behavior such as did by the latter.

van Zeebroeck (2007) discussed some patent filings strategies result in substantial delays in the examination procedure whereas they are not necessarily associated with higher maintenance rate when he analyzed the duration of patent examination in EPO. The closest equivalent of these filings strategies in US is continuation application, continuation in parts and division. Although patent continuation application may be not allowed according to Japanese Patent Law, if a firm consider to use this kind of filing strategy in a sense, self–citation which is involved in the activity may have different effect on the evaluation of the patent such as did by external citations.

It is not clear that the effect of citations on the value of patented innovation should differ according to whether they are self–citations or not. However, some literature argued that self-citations may provide very different signals than do external citations regarding the value to the firm of the subsequent down-the-line technologically connected innovations. Hall et al. (2005) indicated that firms citing their own patents may be a reflection of the cumulative nature of innovation, then "increasing returns" property of knowledge accumulation. In their analysis of the U.S. firms, the firm's market value of the firms is revealed to be positively correlated with self-citations received

by the firm. This relationship is also confirmed in Zhang et al. (2008) for Japanese companies. Therefore, self-citations would suggest that the firm is strongly competitive in a particular technology, and is in a position to internalize some of the knowledge spillovers created by its own developments to lower costs and to earn higher profits. If so, as a value index of patent, self-citation should include more information than that of external citation.

In addition to the number of claim, forward self–citation and external citation, Hall et al. (2001) indicated that "Generality" and "Originality" may more accurate than the total number of forward and backward citations, as the index of impotent and value of patent. A high score of "Generality" suggests that the patent presumably had a widespread impact, in that it influenced subsequent innovation in a variety of technology fields, while "Originality" is defined in the same way, except that it refers to citations made. These consideration then lead the following hypothesis,

Hypothesis IV. Besides the number of claim, and forward self–citation and external citations, there are many other kinds of patent properties, such as "Generality", and "Originality" which may effect the examination request time.

3.3 Variables definitions

With respect to filing strategies or strategy change

Firm size, *Employment*, R&D Intensity, $R\&D/S$ and Patent Propensity, $P/R\&D$: We use *Employment*, $R\&D/S$ and $P/R\&D$, which are measured as the log of number of full time employees, the ratio of the stock of R&D to the total sales and the stock of patent applications to the stock of R&D respectively[5], to show the experience and capability in innovation, IPR or the patent strategy of Japanese companies in their examination request behavior.

Filing of rivals, *ExSameClass*, and filing made by own company, *SlSameClass*: The indexes of competition filing are measured by number of filing from rivals in the same technology field based on the IPC, and the ratio of number of filing made by own company to total filing in the same field respectively.

Dummy for license, *License*: We use a dummy for license registration in Japanese National Center for Industrial Property Information and Training (INPIT). If a patent is considered licensable, the company may register it in the web of INPIT to show the will of trade. Although the registration happens after granted, we assume here that the applicant has decided whether or not to license this patent when the patent was filed. Thus, dummy for registration is expected to correlated with accelerating request activity for holding the patent earlier.

Joint application, *Joint*: We also add joint application dummy in our empirical analysis to show the correlation between open innovation and request. *Joint* is defined as 1 if applicants come from two or over companies.

With respect to impotence and value of patent

Claims, *Claim*: Before 1976, Japanese patent law allowed only one independent, single claim to be included in an invention. After an 1976 amendment and the 1988 reforms, patent applicants can define the coverage of an invention with multiple claims

[5]The stocks of R&D and patent applications are built both in 15% depreciation rate.

(Skakibara and Branstetter (1999)). Here we use number of claims made by the applicants in the date of filing.

Forward External Citation, $ExCitation$, and Forward Self–Citation, $SfCitation$: We utilize 3 year forward external citation numbers for all our samples, and $SfCiation$ refers to number of citations made by own company.

Generality and *Originality*: Two variables are computed based on the method proposed by Trajtenberg et al. (1997) and discussed in Hall et al. (2001).

4 Empirical Results

4.1 Data Source

In addition to patent data which are collected from the dataset of Institute of Intellectual Property (IIP), we obtain information on R&D expenditure, number of employee and sales for Japanese listed companies from the NEEDS's Corporate Financial Report. We attempt to use NIKKEI KAISHA CODE to link the financial data with the data of JPO patent applicants. As a result, we obtain data of 214 listed companies for Japanese electrical and electronic manufacturing sector. We also collect 13,740 license registrations made by these companies in the web of Industrial Property Information and Training (INPIT), which shares approximately 30% of total registrations in INPIT. Table A1 presents some descriptive statistics of our samples.

4.2 Estimated Results

Main findings

The estimated results from the Weibull regression are presented in Table 2. The estimated coefficients reported here can be interpreted as contributions to the rate of hazard, say, request. A positive coefficient induces a proportional increase in the hazard rate for request activity, say, a high probability to request. Therefore, a significant positive coefficient suggests that the variable has an effect on preceding examination request activity.

The coefficient of *Claim* carries the expected sign for the period of 1988-1992 and 1999-2001. That is quite coincided with the results reported by Nagaoka et al. (2007) and Nakamura and Odagiri (2007). In the period of 1993-1998, however, the coefficients reveal significantly negative.

the number of filings made by rivals in the same IPC field, *ExSameClass*, and the ratio of number of filings made by own company to total filings in the same IPC field, *SlSameClass*, show somewhat mixed results during the period of 1988-1992, and turn significantly positive during the periods of 1993-1998 and 1999-2001. We will discuss these two variables further in the regression with time-varying factors.

Both of coefficient of *ExCitation* and *SlCitation* are also positive and statistically significant. For example, the coefficients of *ExCitation* and *SlCitation* are estimated with 1.08 and 1.29 in the period of 1988-1992. These means that a patent with one forward external citation or one forward self-citation faces a hazard (i.e., probability to request) that is 1.08 or 1.28 times as high as a patent that receives no such citation. Therefore, highly cited patent tends to make examination request earlier than that of patent which is cited less. During the three periods, the coefficients of *SlCitation* vary between 1.13 and 1.29, while those for *ExCitation* are approximately between 1.01 and 1.08, implying that the former has been having more effect on the early examination request process than the latter.

Introduced as the index of impotence and value for the patents, *Originality* shows significantly positive across the three periods, and the magnitude of coefficients are quite large. However, the estimated results of *Generality* is not so clear. It is the same case for joint application, *Joint*.

As discussed in hypothesis I, "The companies with more experiences in innovation or IPR are more likely to delay their request activities," and hypothesis II, "Changes

of innovation and IPR environment and strategy in the late of 1990s may lead earlier request activities," we place emphases on the changes and their effects on the behavior of request. The estimated results for behaviors of Japanese electrical and electronic manufacturers in innovation and patenting, in terms of *Employment*, $R\&D/S$ and $P/R\&D$, reveal very impotent implications on these issues. During the period of 1988-1992, all coefficients of *Employment*, $R\&D/S$ and $P/R\&D$ are estimated as significantly negative. These results associated with very significant reduction in the hazard rate, imply that companies with large scale, high R&D intensity and patent propensity, have a tendency to delay their request activity in the early 1990s.

In contrast to the early 1990s, those for *Employment*, $R\&D/S$ and $P/R\&D$ turn to be positive with strong significance in the period of 1999-2001. The firm with large scale, high R&D intensity and propensity to patent may maintain a large staff of patent attorneys and rich experience on evaluation of the invention the firm made. If the environment in IPR and evaluation system changes, these factors may lead to accelerate earlier process of examination request. Furthermore, it is worthy to note that R&D intensity, $R\&D/S$, appears quite large hazard rates between 42.9 and 54.0, suggesting that the companies with high R&D intensity play a vital role in acceleration of examination request happened in the late 1990s in Japan.

In order to further assess the robustness of the estimated results in Table 2, we utilize alternative regression technique for the same sample. Table 3 presents the Ordered Probit estimates with robust t statistics, where the dependent variable is defined as 0, 1, and 2 for the request not happened, happened after and before 18 months after filing respectively. Thus, the significantly positive estimates here may be interpreted as having a positive influence on the early request and high request ratio as well. Except for the estimates for *Employment* in one of the regression specifications in period of 1988-1992, the signs of coefficients for the periods of 1988-1992 and 1999-2001 are all fairly consistent with the results shown in Table 2.

Weibull regression mixed with request ratio

To examine how the explanatory variables influence the length of request time, as well as the request ratio simultaneously, we attempt to apply Mixture Cure Fraction Model proposed by Lambert et al. (2005) and Lambert et al. (2007) in our case. Mixture cure fraction model[6] is defined as the follows.

$$S(t) = S^*(t)(\pi + (1-\pi)S_u(t))$$

where π denotes the proportion of the applications which never request, and $S_u(t)$ is survival function for the applications requested. On the hazard scale, this expression becomes as,

$$h(t) = h^*(t) + \frac{(1-\pi)f_u(t)}{\pi + (1-\pi)S_u(t)}$$

According to Lambert (2007), both $S^*(t)$ and $h^*(t)$ are obtained from external sources, usually from routine data. Lambert (2008) proposed three different functions for π, i.e., the identity link, $\pi = \beta x$, the logistic link, $\log(\pi(1-\pi)) = \beta x$ and the log(-log) link, $\log(-\log \pi) = \beta x$. Table 4 presents the results obtained from fiting the Weibull distribution for the survival and the logistic link for π.

Since the π denotes the proportion of the applications which never request, the significantly negative estimates are associated with high log odds of request ratios. The

[6]see Lambert (2007) for the detailed model and stata commands

estimates of $\log(\lambda)$ corresponds to the estimates of Weibull regression in log relative hazard form. Therefore, a positive coefficient induces an increase in the rate of hazard, and leads an early request.

The estimated coefficients of $\log(\lambda)$ are quite coincided with those obtained in Table 2 for the periods of 1988-1992 and 1999-2001, except for *ExSameClass* in some cases. The estimated results for π, however, are somewhat mixed, and sensitive to the regression specifications. Generally speaking, number of claims, *Claim*, forward external citation, *ExCitation*, forward self-citation, *SlCitation*, R&D intensity, $R\&D/S$, and size of firm, *Employment*, are correlated with high log odds ratio of request, that reconfirms to a certain extent the findings in Nagaoka et al. (2007). The message from some other variables such as *Originality* is not so clear.

The effect of registration for license

In order to investigate the effects of license registration, we collect 5191, 6698 and 1391 license registrations for the periods of 1988-1992, 1993-1998 and 1999-2001 respectively. To compare those data with all other variables, we take a random 10% sample for each period. The Weibull regression results is presented in Table 5. Although the new sample includes only 10% of original sample, the major findings in Table 2 is not undermined by the those shown in Table 2. On the other hand, the coefficients of *License* reveal significantly positive, suggesting that the patent which has been considered to be licensable in the future, is associated with early request for examination after its filing.

The effect of time-varying factors

As discussed in our hypothesis, number of filing made by rivals may vary over time during the whole period between filing and request. To compete with the rivals, a company's decision on when to request, and whether or not to request may be correlated with the actions of the rivals in this period. In order to explore the effects of time-varying factors, we split the records for *SlSameClass* and *ExSameClass* at three intervals, i.e., (0, 24], (24, 48] and (48, 72], and the three intervals refer to the points of 2nd, 4th and 6th year after filing. New values for the two variables are obtained by accumulating the number of filing made by rivals or by own company at 0, 24, 48th month after filing. The Weibull regression results are reported in Table 6. When the time-varying factors are involved, the estimates of *ExSameClass* turn all significantly positive across the different regression specifications during the period of 1988-1992. These are different with that shown in Table 5. The positive sign for *ExSameClass* in period of 1988-1992 and for *SlSameClass* may imply that in the early 1990s, rival's action is quite concerned in the decision of request, whereas in the late 1990s, the companies turn to pay more attention on own patent portfolios.

5 Conclusion

In this paper, we examine the relationship between patent filing activity (i.e., the length of period between filing and examination request, and the request ratio) and the impotence or value of the patent and the patent strategy used for 214 Japanese electrical and electronic manufacturing firms between Jan. 1, 1988 and Sept. 30, 2001.

Using survival analysis techniques, we find that, on the one hand, the indexes related to the value of patents, including the number of claims, originality, forward self-citation and external citation, are positively related to early examination request

through the most periods of our sample. On the other hand, joint-application, which may indicate the changes in open innovation in Japanese firms, and generality show somewhat mixed effects on the request activity.

The estimated results related to characters of the firms, i.e., experience, capability or strategy in innovation and IPR show that, in the early 1990s, large scale firms and firms with high R&D intensity and patent propensity had a tendency to delay their request activity. But during the late 1990s, they turn to accelerate the request activity. And the patent that has been considered to be licensable in the future, is associated with early request.

We also examine the importance of time-varying factors, and attempt to use a Lambert's mixture cure fraction regression technique to estimate the request time and request ratio simultaneously. Our findings show that, including time-varying factors gives different results for the effect of the term related to competition filing, and in most cases, the number of claims, forward self-citation and external citation, R&D intensity and scale of firms are positively related to the high request ratio and early request as well.

Our analysis shows what changes occurred implicitly in innovation and IP strategy in Japanese electrical and electronic firms and how those changes influenced their patent filing behavior due to some happenings of IPR, i.e., a series of patent lawsuits happened between the US and the Japanese semiconductor in the late of 1980s, and increasing patent litigations followed after that. As a strategic Japanese companies responded to them by re-constructing their patent rewarding system for researchers in the 1990s. Our analysis reveals that the changes occurred in innovation and IP strategy in Japanese electrical and electronic firms did influence their patent filing behavior in the following years.

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Figure 1: Examination Request in JPO Patent

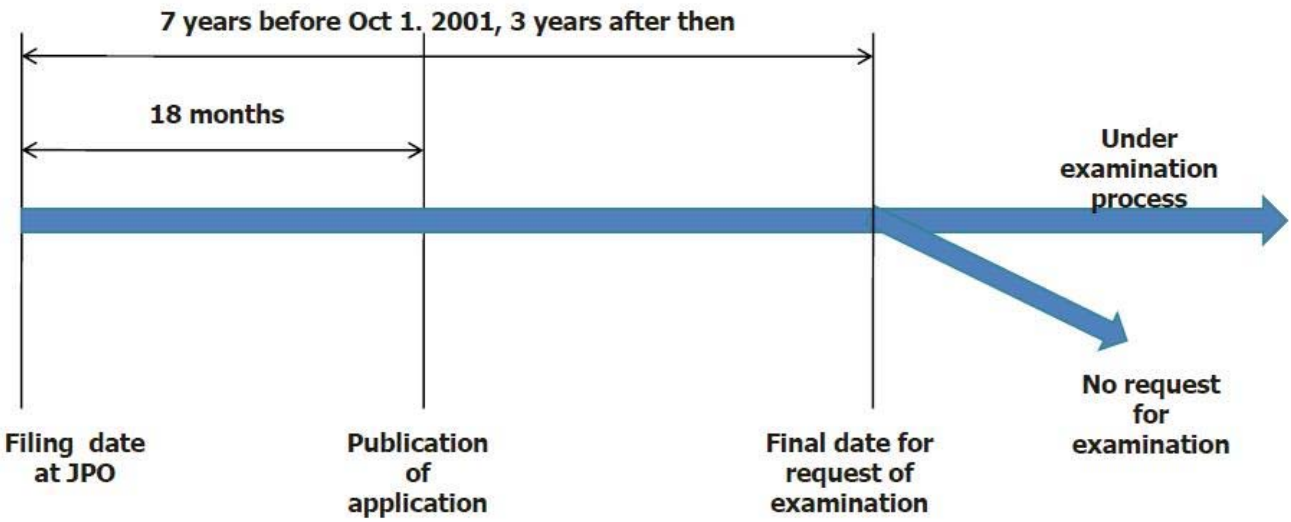

Figure 2: Histogram of Date for Request

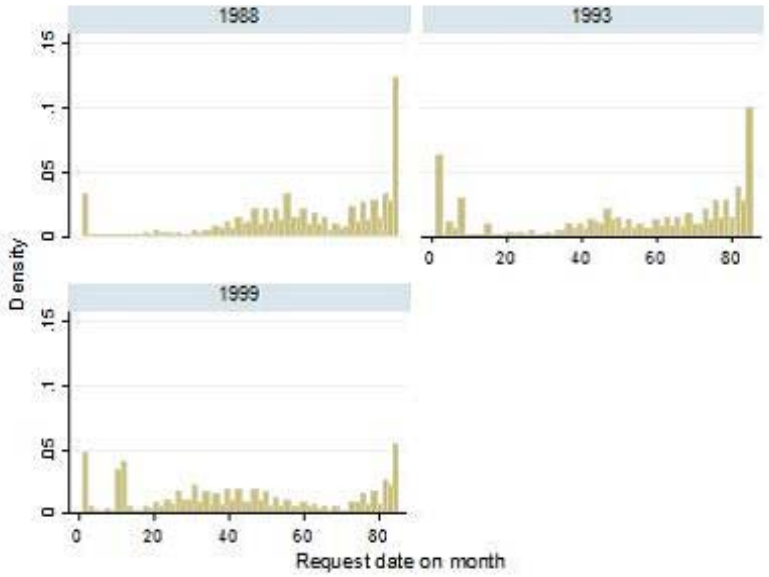

Figure 3: Kaplan-Meier Survival Estimates

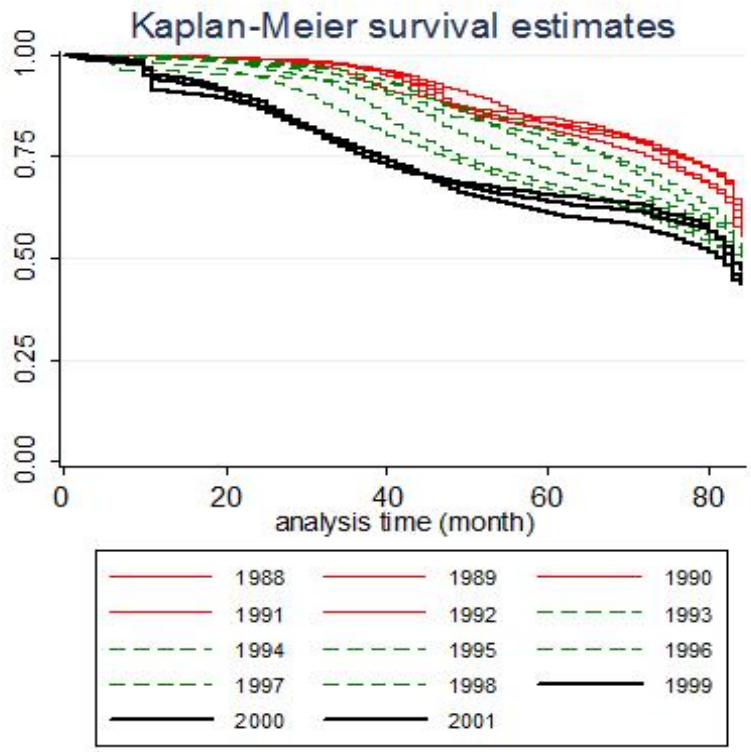

Figure 4: Nelson–Aalen Estimates

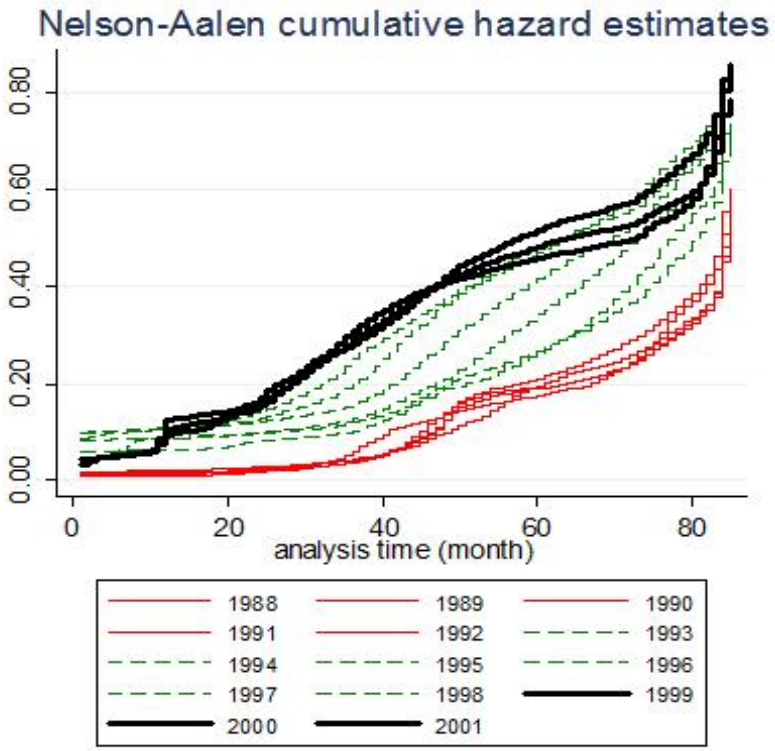

Table 1. Log-rank Test for Trend

Period	Events observed	Events expected
1988-1992	274903	360192.5
1993-1998	328520	278981.5
1999-2001	152257	116506
Total	755680	755680
	chi2(2) =	40826.56
	Pr>chi2 =	0
Test for trend of survivor functions		
	chi2(1) =	37593.23
	Pr>chi2 =	0

Table 2. Weibull Estimates of Hazard Ratio[1]

	1988-1992		1993-1998		1999-2001	
Claim	1.0375	1.0289	0.9949	0.9906	1.0076	1.0051
	(25.11)[2]	(18.35)	(-7.47)	(-13.47)	(13.05)	(8.01)
SlSameClass	1.0087	1.1819	9.0370	10.8904	5.7981	5.6544
	(0.23)	(4.37)	(63.55)	(68.54)	(27.73)	(28.36)
ExSameClass	0.9934	0.9996	1.0037	1.0088	1.0003	1.0061
	(-12.46)	(-0.77)	(6.18)	(14.77)	(0.45)	(8.40)
ExCitation	1.0845		1.0033		1.0142	
	(34.22)		(1.95)		(5.02)	
SlCitation	1.2862		1.1532		1.1349	
	(48.18)		(35.81)		(16.31)	
Joint		1.0959		0.7128		1.0996
		(6.70)		(-28.82)		(7.96)
Originality		14.7937		4.2974		7.2292
		(152.70)		(102.97)		(98.00)
Generality		1.4121		0.9129		0.8662
		(13.10)		(-4.56)		(-4.42)
Employment	0.8944	0.9228	2.8876	2.8721	1.0861	1.0780
	(-24.77)	(-17.71)	(214.60)	(213.68)	(13.01)	(11.54)
R&D/S	0.0858	0.1048	1.9181	1.3247	42.9241	53.9854
	(-14.64)	(-13.51)	(7.82)	(-13.51)	(13.40)	(13.96)
P/R&D	1.0000	1.0000	0.9984	0.9984	1.0024	1.0024
	(-12.48)	(-13.51)	(-13.51)	(3.37)	(73.00)	(71.54)
p	2.5379	2.6142	0.6843	0.7007	1.0395	1.1255
$1/p$	0.3940	0.3825	1.4613	1.4272	0.9620	0.8885
no. of obs	188505	188505	131321	131321	56056	56056
log likelihood	-137711.0	-130040.4	-209504.7	-205005.2	-79132.6	-75060.9
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(1). The estimates are obtained in Weibull regression in the PH metric, and the estimation includes dummy variables for technological fields and application year.

(2). The values in ( ) are t-statistics.

Table 3. Estimates on Ordered Probit Regression[1]

	1988-1993		1994-1998		1999-2001	
Claim	0.0231	0.0203	-0.0043	-0.0069	0.0095	0.0059
	(18.62)[2]	(16.26)	(-6.01)	(-9.76)	(13.29)	(8.15)
SlSameClass	-0.0076	0.1206	2.4153	2.6653	1.8488	1.9398
	(-0.27)	(4.24)	(45.09)	(49.30)	(24.93)	(25.64)
ExSameClass	-0.0039	0.0006	0.0061	0.0133	-0.0009	0.0049
	(-10.45)	(1.54)	(8.71)	(18.57)	(-1.24)	(6.52)
ExCitation	0.0653		0.0076		0.0110	
	(29.66)		(3.90)		(3.39)	
SlCitation	0.2425		0.1753		0.1194	
	(44.82)		(29.35)		(12.15)	
Joint		0.0088		-0.1986		0.1261
		(0.86)		(-15.65)		(10.15)
Originality		2.5417		1.6755		1.7283
		(142.00)		(94.43)		(73.83)
Generality		0.2959		-0.1124		-0.1582
		(14.42)		(-5.05)		(-4.65)
Employment	-0.0044	0.0075	0.7157	0.7355	0.0765	0.0491
	(-1.37)	(2.30)	(179.73)	(180.64)	(12.49)	(7.51)
R&D/S	-1.9877	-1.9092	0.0334	-0.2360	4.3744	4.5556
	(-18.24)	(-17.17)	(0.44)	(-3.06)	(16.45)	(16.68)
P/R&D	0.0000	0.0000	-0.0010	-0.0010	0.0028	0.0030
	(-28.38)	(-27.90)	(-144.52)	(-145.26)	(86.58)	(83.64)
no. of obs	213616	213616	109354	109354	56558	56558
log likelihood	-166107	-156754	-94254	-89998	-50901	-48040
Pseudo R^2	0.0693	0.1217	0.2149	0.2503	0.1713	0.2179

(1). The estimates are obtained on Ordered Probit Regression, where ordinal dependent variables are 0, 1, 2 for non-request, request after and before the publication. The estimation includes dummy variables for technological fields and application year.
(2). The values in ( ) are robust t-statistics.

Table 4. Weibull Estimates Mixed with Request Ratio[1]

	1988-1992				1999-2001			
	$Logistic(\pi)$	$\log\lambda$	$Logistic(\pi)$	$\log\lambda$	$Logistic(\pi)$	$\log\lambda$	$Logistic(\pi)$	$\log\lambda$
Claim	-1.7117	0.0367	-0.8796	0.0240	-0.0125	0.0035	-0.0058	0.0028
	(-5.54)[2]	(24.60)	(-10.79)	(14.02)	(-2.65)	(5.18)	(-1.06)	(4.18)
SlSameClass	13.3344	0.9365	9.1784	1.3087	-13.6217	1.4518	7.6479	2.1588
	(21.76)	(18.08)	(19.14)	(26.52)	(-12.74)	(21.92)	(15.58)	(33.51)
ExSameClass	0.1100	-0.0010	0.0521	0.0052	0.0058	0.0012	0.0010	0.0073
	(11.78)	(-1.61)	(8.09)	(7.94)	(1.63)	(1.62)	(0.18)	(10.16)
ExCitation	-0.2083	0.0784			-0.1465	0.0084		
	(-4.68)	(30.90)			(-5.45)	(2.76)		
SlCitation	-0.1927	0.2423			-0.9877	0.1141		
	(-2.93)	(43.42)			(-6.71)	(13.69)		
Joint			0.0354	0.1224			1.3411	0.1631
			(0.47)	(7.36)			(14.85)	13.76
Originality			-126.04	2.4898			-108.78	1.8133
			(-0.02)	(117.72)			(-0.02)	85.29
Generality			-1.0869	0.3221			-0.9184	-0.1351
			(-4.00)	(11.12)			(-2.30)	-4.02
Employment	-0.4655	-0.1253	0.1241	-0.0871	-0.4885	0.0229	-1.6740	0.0095
	(-3.18)	(-27.55)	(0.82)	(-17.38)	(-12.18)	(2.85)	(-24.58)	(1.39)
R&D/S	-1186.25	-3.0634	-513.21	-3.0671	-958.63	1.9317	0.6958	3.9374
	(-10.23)	(-18.41)	(-6.38)	(-18.24)	(-10.29)	(6.00)	(0.33)	(13.55)
P/R&D	0.0000	0.0000	0.0000	0.0000	0.0006	0.0032	0.0109	0.0030
	(0.42)	(-13.59)	(0.25)	(-13.12)	(2.46)	(87.57)	(19.35)	(82.46)
Const	0.5831	-10.9744	-4.1348	-11.8573	3.2436	-5.4876	8.4341	-5.9651
	(0.39)	(-187.40)	(-2.61)	(-188.63)	(9.29)	(-72.60)	19.61	(-92.74)
$\log\gamma$		0.9382		0.9729		0.1048		0.1529
		(265.05)		(275.17)		(23.95)		(35.60)
no. of obs		188505		188505		56056		56056
log likelihood		-428625		-420567		-200282		-196282
Prob>chi2		0.0000		0.0000		0.0000		0.0000

(1). The estimates of *pi* denotes the ratio of non–request applications

(2). The values in ( ) are t-statistics.

Table 5. Weibull Estimates of Hazard Ratio for random 10% Sample[1]

	1988-1992		1993-1998		1999-2001	
Claim	1.0250	1.0257	0.9981	0.9947	1.0109	1.0063
	(5.78)[2]	(5.60)	(-0.97)	(-2.60)	(5.19)	(2.96)
License	3.0142	2.2029	1.5288	1.3520	2.5813	2.3573
	(15.86)	(11.11)	(8.40)	(5.98)	(14.44)	(12.30)
SlSameClass	0.8948	1.0306	12.2611	13.5426	5.7883	6.3509
	(-0.93)	(0.25)	(22.51)	(23.97)	(8.32)	(8.76)
ExSameClass	0.9950	1.0012	1.0002	1.0057	0.9974	1.0033
	(-3.03)	(0.75)	(0.09)	(3.12)	(-1.19)	(1.47)
ExCitation	1.0973		0.9981		1.0121	
	(11.67)		(-0.41)		(1.35)	
SlCitation	1.3035		1.1116		1.1431	
	(13.81)		(9.97)		(4.84)	
Joint		1.0578		0.7229		1.0866
		(1.29)		(-8.81)		(2.24)
Originality		13.5868		3.7954		6.8246
		(46.79)		(30.50)		(30.15)
Generality		1.3862		0.8887		0.9272
		(4.03)		(-1.98)		(-0.77)
Employment	0.8929	0.9257	2.8375	2.8266	1.0825	1.0729
	(-8.02)	(-5.42)	(67.86)	(67.95)	(3.88)	(3.38)
R&D/S	0.0943	0.0929	1.9089	1.5069	47.1669	66.1524
	(-4.60)	(-4.64)	(2.47)	(1.57)	(4.08)	(4.32)
P/R&D	1.0000	1.0000	0.9984	0.9984	1.0023	1.0024
	(-2.61)	(-2.42)	(-55.44)	(-55.03)	(22.35)	(22.41)
p	2.5135	2.5789	0.6906	0.7045	1.0598	1.1445
$1/p$	0.3979	0.3878	1.4479	1.4194	0.9435	0.8738
no. of obs	19054	19054	13571	13571	5731	5731
log likelihood	-14023	-13304	-21878	-21462	-8110	-7719
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(1). The estimates are obtained in Weibull regression in the PH metric, where the observations are obtained by taking a random 10% sample for each period. The estimation includes dummy variables for technological fields and application year.

(2). The values in ( ) are t-statistics.

Table 6. Weibull Estimates of Hazard Ratio with Time-varying[1]

	1988-1992		1993-1998		1999-2001	
Claim	1.0240	1.0249	0.9992	0.9956	1.0108	1.0065
	(5.53)[2]	(5.42)	(-0.42)	(-2.18)	(5.14)	(3.04)
License	3.0008	2.1894	1.4802	1.3227	2.5061	2.3105
	(15.80)	(11.03)	(7.81)	(5.57)	(13.97)	(11.99)
SlSameClass	0.6873	0.7708	19.3596	20.8719	17.0600	16.5655
	(-2.45)	(-1.71)	(24.82)	(26.12)	(12.50)	(12.45)
ExSameClass	1.0016	1.0027	1.0090	1.0100	0.9986	0.9998
	(4.85)	(8.18)	(21.74)	(24.35)	(-2.59)	(-0.34)
ExCitation	1.0983		0.9991		1.0132	
	(11.79)		(-0.19)		(1.48)	
SlCitation	1.3128		1.1085		1.1361	
	(14.15)		(9.89)		(4.58)	
Joint		1.0692		0.7428		1.0806
		(1.54)		(-8.06)		(2.09)
Originality		14.1885		4.1287		6.6688
		(47.61)		(32.37)		(29.77)
Generality		1.4363		0.9261		0.9270
		(4.47)		(-1.29)		(-0.78)
Employment	0.8888	0.9251	2.7525	2.7457	1.0809	1.0738
	(-8.34)	(-5.47)	(66.19)	(66.43)	(3.81)	(3.41)
R&D/S	0.1133	0.1098	1.5796	1.2639	41.7774	64.5967
	(-4.25)	(-4.31)	(1.72)	(0.89)	(3.98)	(4.32)
P/R&D	1.0000	1.0000	0.9984	0.9984	1.0024	1.0024
	(-2.73)	(-2.66)	(-55.06)	(-54.66)	(22.62)	(22.73)
p	2.4602	2.4968	0.6504	0.6598	1.0919	1.1625
$1/p$	0.4065	0.4005	1.5374	1.5157	0.9158	0.8602
no. of obs	70049	70049	36438	36438	14364	14364
log likelihood	-14013	-13270	-21669	-21206	-8070	-7687
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(1). The estimates are obtained in Weibull regression in a random 10% sample with time-variables. The estimation includes dummy variables for technological fields and application year.

(2). The values in ( ) are t-statistics.

Table A1. Descriptive Statistics for Variables

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
		1988-1992			
No. of claim	655847	2.32	2.83	1	272
No. of filing in same filed(IPC)	655862	7771.47	7845.59	0	23863
No. of filing made by own company in same filed(IPC)	655862	640.96	993.81	0	4804
Dummy for joint application	655862	0.09	0.29	0	1
No. of citation received	655862	0.80	1.43	0	60
No. of self-citation received	655862	0.15	0.55	0	35
Generality	655862	0.04	0.13	0	0.88
Originality	655862	0.05	0.15	0	0.92
Sales	655849	2071916	1348903	0	4994719
R&D stock	206711	1065	3815	1	23465
Patent stock	655862	18636	11366	0	35883
No. of employee	571149	41399	23244	79	82221
		1993-1998			
No. of claim	601914	5.80	5.99	1	208
No. of filing in same filed(IPC)	601931	5924.39	5983.30	0	20948
No. of filing made by own company in same filed(IPC)	601931	350.50	509.01	0	2968
Dummy for joint application	601931	0.12	0.33	0	1
No. of citation received	601931	1.17	2.10	0	116
No. of self-citation received	601931	0.22	0.74	0	72
Generality	601931	0.06	0.16	0	0.898
Originality	601931	0.10	0.21	0	0.93
Sales	601913	2099842	1576122	0	4874526
R&D stock	141107	2154	5863	1	27457
Patent stock	601931	11270	7604	0	26109
No. of employee	520754	36790	25661	54	80542
		1999-2001			
No. of claim	269762	8.43	8.60	1	413
No. of filing in same filed(IPC)	269772	6692.75	7006.39	1	29596
No. of filing made by own company in same filed(IPC)	269772	315.37	433.18	0	1830
Dummy for joint application	269772	0.25	0.44	0	1
No. of citation received	269772	0.93	1.74	0	74
No. of self-citation received	269772	0.16	0.59	0	31
Generality	269772	0.05	0.15	0	0.8827
Originality	269772	0.10	0.21	0	0.90
Sales	269764	2174645	1584848	0	4831866
R&D stock	56648	3075	5380	1	21733
Patent stock	269772	10493	7383	0	24886
No. of employee	233548	30856	21330	53	68763

Table A2. Cox Estimates of Hazard Ratio[(1)]

	1988-1992		1993-1998		1999-2001	
Claim	1.0395	1.0306	1.0021	0.9988	1.0079	1.0056
	(26.67)	(19.55)	(3.14)	(-1.78)	(13.58)	(8.76)
SlSameClass	0.9465	1.0777	6.9944	7.5568	4.9988	4.9237
	(-1.43)	(1.95)	(52.01)	(54.08)	(24.66)	(25.14)
ExSameClass	0.9933	0.9998	1.0036	1.0106	1.0001	1.0065
	(-12.63)	(-0.38)	(6.13)	(17.70)	(0.20)	(8.85)
ExCitation	1.0898		1.0141		1.0161	
	(36.35)		(8.49)		(5.69)	
SlCitation	1.2997		1.1524		1.1384	
	(50.82)		(35.28)		(16.84)	
Joint		1.1086		0.9728		1.1202
		(7.54)		(-2.35)		(9.50)
Originality		18.5306		5.1059		7.7114
		(164.22)		(113.17)		(97.75)
Generality		1.4345		0.9780		0.8787
		(13.69)		(-1.11)		(-3.98)
Employment	0.8920	0.9255	2.1259	2.0941	1.0979	1.0861
	(-25.28)	(-16.98)	(161.48)	(159.11)	(14.47)	(12.42)
R&D/S	0.0950	0.1212	1.3679	1.0156	39.2122	46.2915
	(-14.05)	(-12.65)	(3.81)	(0.19)	(13.04)	(13.35)
P/R&D	1.0000	1.0000	0.9988	0.9988	1.0021	1.0021
	(-13.51)	(-12.35)	(-133.33)	(-131.63)	(64.10)	(61.44)
no. of obs	188505	188505	131321	131321	56056	56056
log likelihood	-863873	-855084	-977028	-971845	-408980	-404845
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(1). The estimates are obtained in Cox regression in the PH metric, and the estimation includes dummy variables for technological fields and application year.

(2). The values in ( ) are t-statistics.