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IIR Working Paper WP#08-07

December 2008

Institute of Innovation Research
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http://www.iir.hit-u.ac.jp

# Complementary Reforms of Patent Examination Request System in Japan

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**Abstract**
The number of requests for patent examination showed a significant increase of 83% from 1997 to 2007 in Japan, while the number of patent applications increased by only 1%. This paper aims at theoretically and empirically analyzing the causes of recent "explosion" of examination requests, focusing especially on (1) the introduction of multiple claim system (January 1, 1988), (2) the shortening of the period available for examination request from seven to three years (October 1, 2001) and (3) the revisions of examination request fee and annual fee (April 1, 2004). We test the following propositions which are derived from the theoretical model; (a) the increase in the average number of claims increases the value of applications and raises the rate of examination request; (b) the shorter period of examination request increases the probability that the low-quality applications are requested for examination; and (c) the reforms of examination request fee and renewal fee improve the average quality of applications which are requested for examination. Our empirical results support these propositions.

*JEL classification numbers:* C41, L21, O34
*Keyword:* patent examination, option value, claim, R&D

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## 1. Introduction

Under the Japanese patent system, an applicant (or a third party) has to request for the examination within three years from the date of application if it pursues to patent its invention (or if a third party wants to clarify the patentability)[1]. That is, the Japan Patent Office (JPO) examines the applications only after the firms' requests for examination. This examination request system gives the firm the time to sort out the inventions which deserve patent protection. The aim of this system is to save the cost of patent examination and to decrease the stocks of unnecessary patent grants which can constrain the rival firms' innovative activities. Thereby, the public knowledge pool is enlarged by saving the social cost of examination without loss of applicants' benefit.

In Japan, the patent examination request system was introduced in 1971. Until the end of September in 2001, the allowable period of request for examination had been seven years. This period was reduced to three years in October 2001. We expect this revision to reduce the stocks of unexamined applications which can block rival firms' production and R&D behaviors. The low-quality patent applications, when they are left unexamined, can hinder the emergence of new valuable inventions. The shortening of the period of examination request decreases this negative effect on social welfare. However, it also has an adverse effect of increasing the number of low-quality applications for which examinations are requested since it makes firms difficult to assess the real quality of their inventions. Some of these patent applications would be granted patents, constraining the third party.

This effect can be offset by the modifications of fee structure in April 2004. The JPO raised the examination request fee and decreased the annual fee. In this revisions, the total fee for the patents with relatively lower quality rises, whereas for the relatively high-quality patents it decreases. This improves the social welfare by decreasing the examination requests for the low-quality applications and increasing the share of high-quality patents. Therefore, these two recent reforms of patent examination request system in Japan can be regarded as complementary policy means.

There are few researches who directly address the issue of an examination request, except for Palangkaraya et al. (2008). Palangkaraya et al. (2008) shows that the grant rate is negatively correlated with the timing of examination request. According to their view, this provides the evidence that the applicants use their private knowledge about the quality of their inventions to distort the rival firms' R&D activities by delaying the timing of examination request. Regibeau and Rockett (2003) theoretically analyses the relationship between the examination duration and the importance of patents. They argue that shorter duration of patent examination improves the social welfare as long as the incentive of firms to develop high-quality inventions is assured. Shorter examination duration lowers the accuracy of examination and increases the social welfare. This is because social welfare is improved when Patent Office mistakenly refuses high-quality inventions to grant patents.

This paper, differently from these studies, focuses on the impact of recent policy reforms in Japan on firms' examination request behaviors. The number of requests for examination showed a significant increase of 83% from 1997 to 2007 in Japan, while the number of patent applications increased only by 1%. This paper aims theoretically and empirically to analyze the causes of the recent explosion of examination requests, focusing especially on (1) the introduction of multiple claim system, (2) the shortening of the

[1] The patent examination request by third party is very limited. In the rest of the paper we ignore this channel of patent examination.

request period available for examination from seven to three years (October 1, 2001) and (3) the revisions of examination request fee and annual fee (April 1, 2004). The following propositions are derived from the theoretical model.
(Ⅰ) The increase in the value of patents, which can be measured by the number of claims, raises the rate of examination request.
(Ⅱ) If the examination request period is shortened, the average quality of the applications for which examinations are requested becomes lower since the uncertainty increases. This raises the rate of examination request.
(Ⅲ) The increase in the examination request fee makes firms screen out the low-quality applications, and the decrease in the annual fee is more advantageous for the long-life patents with high quality.

The following our empirical findings are consistent with these propositions.
(i) Firms which file the application for a patent with large number of claims or which increase the number of claims over time show higher rates of examination requests.
(ii) The shortening of the period of examination request results in a sharp rise in the examination request rate. This policy change has a large effect especially on the firms facing high uncertainty.
(iii) The revisions of the fee structure increased the average quality of applications which are requested for examination. This is because the reforms are cost reducing for the firms having high-quality applications, whereas they are fare hike for the firm which files low-quality applications.

The shortening of the examination request period is expected to prevent firms from leaving applications with little patentability unexamined. We find, however, that this change has the effect of increasing the examination requests of low-quality inventions and decreasing the social welfare because of the increase in the uncertainty. On the other hand, the reforms of fee structure which decrease the expected total fee for high-quality patents and increase for low-quality ones ofsetts at least partially the negative effects on social welfare caused by the shortening the allowable period. We can, therefore, say that these system reforms are complementary to each other.

The rest of this paper is organized as follows. In section 2, we provide a model which can explain the relationship between firms' examination request behaviors and the policy reforms. Section 3 empirically analyze the impact of reforms of examinaiton request system. Section 4 concludes the paper.

## 2. A theoretical Model

### 2.1 Outline

Some patent applications do not need an immediate exclusive right because of the uncertainty of its timing of commercialization. One of the purposes of examination request system is giving firms a certain period to sort the useful inventions. This system saves the resources related to examination and expands the public knowledge anyone can access, without losing the applicants' benefit. Firms can effectively protect their technology by the patent registration. They, however, have to pay the annual fee to keep a patent in force. Therefore, it is rationale for firms to postpone a decision-making of examination requests if they do not have a prospect of using the inventions in near future. Considering these cost and benefit of a patent, firms decide which and when to request for examination of their applications.

This type of decision-making is analogous to the firms' investment problem under the

uncertainty. It has considerably different characteristics from the decision-making of patent applications closely related to the competition with rival firms.

Under the examination request system, the applicants have the right to request for examination anytime they want within the allowable period. That is, the examination request system gives the applicants an option value for their applications. By delaying the examination request, the applicants can gain time to evaluate the inventions at the expense of opportunity cost of patent. In other words, the merit of delaying a decision for firms is that they can acquire additional information and decrease the uncertainty, whereas the demerit is that the periods of patent protection are shortened. In this section, we model this tradeoff and analyze the impact of shortening period of examination request and the amendments of fee schedule on firms' incentive to request for examination.

There are some useful studies which address the decision-making of patent renewals, though few researches directly analyze the examination request system. The problems of examination request and patent renewal have common nature that both are the decision-making under the uncertainty where the value of patents/applications gradually becomes clear as time passes. Pakes (1986) is a pioneer work which provides the theoretical model of patent renewal. He, furthermore, simulates the option value of patens by using the historical data of patent renewals in three Patent Offices (France, Germany and United Kingdom). Using the Pakes's approach, Deng (2006) analyzes the changes in the value of patents after the establishment of the EPO[2].

The models developed in these previous studies are based on real option theory[3]. The strength of real option theory is that it can analyze the flexibility of decision-making. That is, it is well suited for the analysis of the problems such as the postponement or the abandonment of investment corresponding to the given situation at each stage[4]. In the next subsection, we develop a simple model to analyze the firms' examination request behavior using the comparative statics based on the idea of real option approach.

### 2.2 Framework

First, we divide the allowable period of examination request into two periods ($t = 1, 2$). Therefore, each period means 3.5 years if examination request period is 7 years, and 1.5 years if maximum request period is 3 years. The decision making of a firm in period $t$ is described as follows. At the beginning of period $t$, the firms decide whether they request for examination of their application or not. In this stage, their decision is based on the subjective value of the application $i$, $q_{i,t}$, without knowing the true value $\hat{q}_i$[5]. The true value of the application $i$, $\hat{q}_i$, is log-normally distributed, and its mean is $\mu$ and variance is $\sigma^2$. Thus we can write as $\log(\hat{q}_i) \sim N(\mu, \sigma^2)$. Each firm experimentally knows the average value of the real quality of applications, $\mu$, whereas they do not know the distribution of the true value. That is, each firm behaves based on the distribution of their own expectations about the quality[6]. Delaying the decision, the firms can acquire the additional information about the availability of their application. This approximates firms' expected value of the application to the true value. This relation can be formulated as below.

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[2] There are other studies, such as Cornelli and Schankerman (1999), which theoretically analyze the patent renewals system.

[3] Pitkethly (1999) reviews the approaches to assess the patent value focusing on the option theory.

[4] Hubbard (1994) and Weeds (2002) analyze the rationality of delaying the investment by using the real option theory.

[5] The variable $q_{i,t}$ includes the probability of being granted.

[6] The distribution of firm $i$'s expectation about the value of an application in period $t$ is common in all firms.

In the beginning of the second period, nature send firms a signal to fill the gap between the expected value and the true value of the application so that firms can revise their expectation. We write this signal in each period $t$ as $(\hat{q}_i - q_{i,t-1} + \delta_{i,t})$, where $\delta_{i,t}$ is a noise which is uniformly distributed over $[-d, d]$ with $\mathrm{E}[\delta_{i,t}] = 0$. Using the signal $(\hat{q}_i - q_{i,t-1} + \delta_{i,t})$, firms estimate the amount of revision of their expectation, since firms can not directly observe the correct revised amount $(\hat{q}_i - q_{i,t-1})$. The estimator $\varepsilon_{i,t}$ is given by

$$\varepsilon_{i,t} = m(\hat{q}_i - q_{i,t-1} + \delta_{i,t}) \quad , \tag{1}$$

where $m$ is a common parameter to all firms. We can derive $m$ as the ratio of the variance of true signal $(\hat{q}_i - q_{i,t-1})$ to that of noise, that is, $m = 1/\{1 + var(\delta_{i,t})/var(\hat{q}_i - q_{i,t-1})\}$. Equation (1) expresses the situation such that firms observe the trend of technology and market so that they can assess more precisely the value of their application.

The firms' expected value of the application in period $t$ is written as following equation.

$$q_{i,t} = q_{i,t-1} + \varepsilon_{i,t} \qquad (t \geq 1) \ . \tag{2.1}$$

In the initial point where firms have no information $(t = 0)$, they expect that their application has an average quality $(q_{i,0} = \mu)$[7]. Thus, we can rewrite equation (2.1) in terms of $\mu$ and $\hat{q}_i$;

$$q_{i,t} = \sum_{k=1}^{t} (1-m)^{k-1} m\left(\hat{q}_i + \delta_{i,k}\right) + (1-m)^k \mu \ . \tag{2.2}$$

This equation shows that firms' expectation get closer to the true value as time passes, and we can obtain $E[lim_{t\to\infty} q_{i,t}] = \hat{q}_i$.

Each firm requests for examination only if the expected value is larger than the critical level at which examination request is profitable. The distribution of the true value of applications, which has log-normality, is ex-ante unobservable for firms.

Let $C$, $\beta_t$ and $S(q_{i,t})$ denote the examination request fee, discount factor in period $t$, and the expected present value of subsequent rent flow from the examination request in period t, respectively. The discounted option value of the application in period $t$ is given by

$$V\left(t, q_{i,t}\right) = max\{\beta_t S(q_{i,t}) - C,\ \beta_t V(t+1, q_{i,t+1})\} \ . \tag{3}$$

Equation (3) means that the discounted present value of holding the right of examination request is either the expected profit of requesting examination in period $t$ or the discounted present value of the right in the next period $t+1$ with delaying the decision. We can consider $S(q_{i,t})$ as the subjective present value of an application after the examination request. The variable $S(q_{i,t})$ is assumed to be taken all factors into account, such as grant rate, renewal term and renewal fee[8].

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[7] When we take the expectation of $\varepsilon_t$ in terms of $i$ and $t$, we get $E_{i,t}[\varepsilon_t] = E\left[q_{i,t} - q_{i,t-1}\right] = 0$. This means the ex-ante average deviation of firms' expectation from the true value is zero.

[8] We assume that firms cannot get revenue if their application is not granted. Therefore, we eliminate the application-only benefit such as blocking and signaling.

When the quality of invention is high the grant rate would be high, and the total cost of annual fee becomes large since the renewal term would be long. For the simplicity, we assume $S$ as following.

$$S(q_{i,t}, \gamma) = (a - b\gamma)q_{i,t} \quad , \tag{4}$$

where $\gamma$ is annual fee, and both $a$ and $b$ are positive constant numbers. Additionally we assume $S(q_{i,0}, \gamma) \geq 0$ because the inventions which satisfy $S(q_{i,0}, \gamma) < 0$ will be abondoned.

### 2.3 Solution

Now, let us derive the solution of the model under the settings above. Each firm requests for examination only if the expected profit of examination request is equal to or larger than the one of not requesting. We can write the firm $i$'s decision-making problem in period $t$ as following equation, where $X_{i,t} = 1$ means the firm $i$ requests for examination and $X_{i,t} = 0$ means the firm does not request for it.

$$X_{i,t} = \begin{cases} 1 & if \quad \beta_t S(q_{i,t}, \gamma) - C \geq \beta_t V(t+1, q_{i,t+1}) \\ 0 & otherwise \end{cases} . \tag{5}$$

Note that the option value of holding the examination request right becomes 0 after the allowable request period expires $(t > T)$. Thus, in our two-period model, the decision-makings of firm $i$ in each period $t$ is given by

$$X_{i,2} = \begin{cases} 1 & if \quad \beta_2 S(q_{i,2}, \gamma) - C \geq 0 \\ 0 & otherwise \end{cases} , \tag{6}$$

$$X_{i,1} = \begin{cases} 1 & if \quad \beta_1 S(q_{i,1}, \gamma) - C \geq \beta_1 V(2, q_{i,2}) \\ 0 & otherwise \end{cases} . \tag{7}$$

In period 2, the firm's revision of the expectation follows $q_{i,2} = q_{i,1} + m(\hat{q}_i - q_{i,1})$ on average. Using this expression and equation (6), we can derive the critical level of real quality in period 2, denoted by $\underline{q_2}$. The application $i$ with $\hat{q}_i \geq \underline{q_2}$ is requested for examination. That is, we can find $\underline{q_2}$ which satisfies the following equation.

$$\beta_2 (a - b\gamma)\{\mu + m(2 - m)(\underline{q_2} - \mu)\} - C = 0 \tag{8}$$

In order to derive the critical level of $\hat{q}_i$ in period 1, $\underline{q_1}$, we have to calculate the following equation (9).

$$\beta_1 S(q_{i,1}, \gamma) - C = \beta_1 Pr[X_{i,2} = 1] \, E[\beta_2 S(q_{i,2}, \gamma) - C \mid X_2 = 1] \tag{9}$$

The right hand side of (9) is the present value of the expected profit of postponing a decision from period 1 to period 2. $Pr[X_2 = 1]$ $(= Pr[\beta_2 S(q_2, \gamma) \geq C])$ is the probability of examination request in period 2. $E[\beta_2 S(q_{i,2}, \gamma) - C \mid X_2 = 1]$ is a firm's expected profit of requesting for examination in period 2. In our model, firms are assumed to get nothing if they do not request for examination $(E[\beta_2 S(q_{i,2}, \gamma) \mid X_2 = 0] = 0)$.

Restricting the range of parameters to hold the condition $Pr[X_2 = 1] \in [0,1]$, we can

derive the critical level in period 1, $\underline{q}_1$, from the following equation[9].

$$\beta_1 (a - b\gamma)\{m\underline{q}_1 + (1-m)\mu\} - C - \frac{\beta_1 A^2}{4\beta_2 (a-b\gamma)md} = 0 \tag{10}$$

where $A = \beta_2 (a - b\gamma)\{m(2-m)\underline{q}_1 + (1-\mathrm{m})^2\mu + md\} - C$.

Let us now analyze the impact of the changes in exogenous variables on these critical levels, $\underline{q}_1$ and $\underline{q}_2$, and thereby, on the examination request profile.

### 2.4 Comparative Statics

Denoting the distribution function of the true values of the applications by $F(\hat{q})$, we can write the rate of request for examination in the first period ($r_1$), the rate of that in the second period ($r_2$) and the eventual rate of examination request ($x$) as following expressions respectively (see Figure 1).

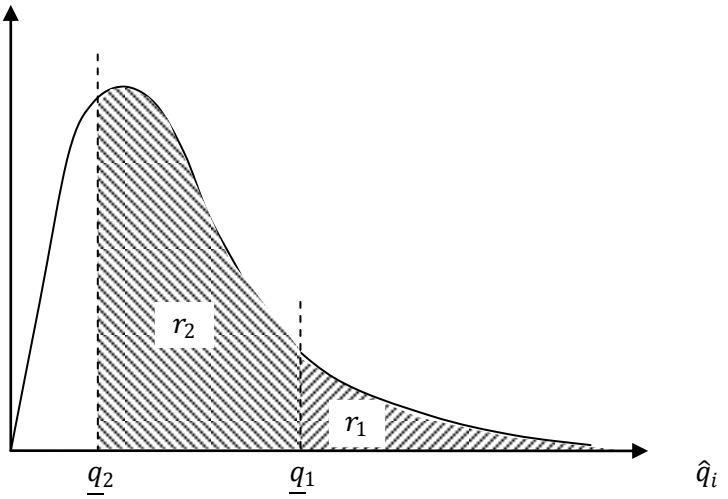
We focus on the realistic case in which the condition $\underline{q}_2 < \mu < \underline{q}_1$ holds. If the lowest quality level where firms request for examination is larger than the ex-ante expected quality level ($\underline{q}_2 > \mu$), firms can not gain a positive expected profit from the application; if $\underline{q}_2 > \underline{q}_1$, the rate of examination request in period 2 is always 0; and if $\underline{q}_1 < \mu$, large part of applications are requested for examination in the early stage, though in point of fact the rate of examination request in early period is quite low in Japan (Yamauchi and Nagaoka, 2007).

$$r_1 = \int_{\underline{q}_1}^{\infty} f(\hat{q})d\hat{q} = 1 - F(\underline{q}_1) \tag{11}$$

$$r_2 = \int_{\underline{q}_2}^{\underline{q}_1} f(\hat{q})d\hat{q} = F(\underline{q}_1) - F(\underline{q}_2) \tag{12}$$

$$x = \int_{\underline{q}_2}^{\infty} f(\hat{q})d\hat{q} = 1 - F(\underline{q}_2) = r_1 + r_2 \tag{13}$$

Figure 1. Rate of examination request in each period




[9] $Pr[X_2 = 1] \in [0,1]$ means that $C$ is limited within a range of $[-dm\beta_2(a-b\gamma)(2-m) + B,\ dm\beta_2(a-b\gamma)(2-m) + B]$, where $B = \beta_2(a-b\gamma)(2-m)\{(1-m)\mu + m\hat{q}_i$.

First, we show the effect of the shortening period of examination request. This is captured by the effect of the decrease in the amount of information, that is, decrease in $m$[10].

$$\frac{\partial \underline{q}_2}{\partial m} = \frac{2(1-m)(\mu - \underline{q}_2)}{m(2-m)} > 0 \ , \tag{14}$$

$$\frac{\partial x}{\partial m} = -f(\underline{q}_2)\frac{\partial \underline{q}_2}{\partial m} < 0 \ , \tag{15}$$

$$\frac{\partial \underline{q}_1}{\partial m} = \frac{\beta_2(a-b\gamma)^2 m^2 d(\underline{q}_1 - \mu) - A(mA_m - A)}{\{A(2-m) - 2d(a-b\gamma)m\}\beta_2(a-b\gamma)m^2} \ . \tag{16}$$

where $A_m = \partial A/\partial m = 2\beta_2(a-b\gamma)(1-m)(\underline{q}_1 - \mu)$ and $(mA_m - A) = -[\beta_2(a-b\gamma)\{m(\underline{q}_1 - \mu) + (1-\mathrm{m})^2\mu\} - C]$. Note that the sign of $\partial \underline{q}_1/\partial m$ becomes negative if $C$ is sufficiently large, though it is generally unclear[11]. We can summarize the effect of shortening period of examination request (decreasing in $m$) as follows.

*Proposition 1*
*If the period of request for examination is shortened,*
*(a) even the relatively low-quality applications come to be requested for examination, and the rate of eventual examination request always rises;*
*(b) the rate of examination request in early period declines and the firms' decision of request tend to be postponed, when the examination request fee is sufficiently large.*

Shortening the examination request period makes it difficult for firms to screen out the low-quality applications. This increases the rate of eventual examination request. Moreover, firms attempt to avert the decrease in the amount of information by delaying their decision so as to request only valuable applications worth the fee. In other words, if the allowable period is shortened, even the low-quality applications are eventually requested for examination, whereas the early requests for examination are limited to high-quality applications.

We now turn to analyze the effect of increase in the examination request fee, expressed as the increase in $C$.

$$\frac{\partial \underline{q}_2}{\partial C} = \frac{1}{\beta_2(a-b\gamma)m(2-m)} > 0 \ , \tag{17}$$

$$\frac{\partial \underline{q}_1}{\partial C} = \frac{\beta_1 A - 2\beta_2(a-b\gamma)}{\{A(2-m) - 2d(a-b\gamma)m\}\beta_2(a-b\gamma)m} \ . \tag{18}$$

We can find $\partial \underline{q}_1/\partial C$ is always positive if $C$ is sufficiently large, though it is generally unclear. In this case, both the rate of eventual request and early request for examination become lower as the examination request fee rises. However, we do not know whether the

[10] We eliminate, for simplification, the situation that the discount factors in each period ($\beta_1$ and $\beta_2$) change depending on the shortening of the allowable period.
[11] Under the condition $Pr[X_2 = 1] \in [0,1]$, the maximum level of $C$ is $\beta_2(a-b\gamma)(2-m)\{(1-m)\mu + m\hat{q} + md\}$. In the case that $C$ is maximum level, $A$ is always negative. Therefore, the critical level of $C$ exists under which $A$ becomes negative.

rate of examination request in the latter period increases.

*Proposition 2*
*If the examination request fee is raised,*
*(a) firms' screening criteria becomes severe and the rate of eventual examination request declines;*
*(b) only high-quality applications are requested for examination in early period, when the examination request fee is sufficiently large.*

The increase in the request fee for examination gives the firm incentive to select out the valuable applications deserving the cost. This increases the threshold to request for examination. As a result, the rate of examination request falls in both the first and second periods.

Next, let us show the effect of the decrease in the annual fee (the decrease in $\gamma$).

$$\frac{\partial \underline{q}_2}{\partial \gamma} = \frac{\beta_2 b\{\mu + m(2-m)(\underline{q}_2 - \mu)\}}{\beta_2(a-b\gamma)m(2-m)} > 0 \ , \tag{19}$$

$$\frac{\partial \underline{q}_1}{\partial \gamma} = \frac{b\{(d-1)A^2 + 2AC\}}{2\{A(2-m) - 2d(a-b\gamma)m\}\beta_2(a-b\gamma)^2 m} \ . \tag{20}$$

In most cases the sign of $\partial \underline{q}_1/\partial\gamma$ becomes positive. Especially, if $C$ is sufficiently large and $d$ is sufficiently small, $\partial \underline{q}_1/\partial\gamma > 0$ always holds[12]. In this case, the decrease in annual fee raises the both rates of eventual and early request for examination. However, whether the rate in later period increases is unclear.

*Proposition 3*
*If the annual fee decreases,*
*(a) the expected profit of patenting becomes large and this leads to the rise in the rate of eventual examination request;*
*(b) the rate of examination request in early period increases, when the examination request fee is sufficiently large and the accuracy of the signal is not so low.*

Under the circumstances that examination request fee is high and the firms can precisely screen out the low-quality applications in early stage, the reduction in annual fee makes the early patenting more advantageous since it prolongs the period of patent protection with high success rates.

Finally, we show the effect of the increase in the average quality of applications ($\mu$) which is regarded as the number of claims in our empirical analysis.

$$\frac{\partial \underline{q}_2}{\partial \mu} = -\frac{(1-m)^2}{m(2-m)} < 0 \ , \tag{21}$$

$$\frac{\partial \underline{q}_1}{\partial \mu} = \frac{2d(a-b\gamma)m - A(1-m)}{\{A(2-m) - 2d(a-b\gamma)m\}m} \ . \tag{22}$$

[12] If $C$ is sufficiently large, A is negative. Therefore, in this case, the denominator of equation (20) is also negative. Moreover, if $d$ is sufficiently small, the numerator of (20) is likely negative. Especially, in case of $1 \leq d$, it is always negative.

We can find $\partial \underline{q}_1/\partial \mu < 0$ always holds if $C$ is sufficiently large. The rise in the average quality of applications enables firms to request for examination of low-quality applications which could not have been requested, by raising the firms' expected profit. That is, the rate of eventual examination request rises as the number of claims becomes large. The distribution of the real quality of applications is skewed to the right with the rise in $\mu$. This raises the rate of early request for examination, coupled with the decline in the firms' critical level of early examination requests. These results are rewritten as follows, from the standpoint of the introduction of multiple-claim system.

*Proposition 4*
*If multiple-claim system is introduced and the average number of claims increases,*
*(a) the rate of eventual request for examination rises because of the increase in the average quality of applications;*
*(b) the rate of early request for examination request becomes high when the examination request fee is sufficiently large.*

When the average quality of applications increases, the necessity for firms to spend lots of time to assess the quality of applications becomes low. This accelerates the firms' examination request behaviors. The expected signs of each variable derived from the model above are summarized in table 1[13].

### 2.5 Further discussion

We briefly discuss the impact of reforms on the social welfare. Some papers examine the socially optimal patent system, though few papers directly treat the examination request system[14]. Cornelli and Schankerman(1999) and Scotchmer(1999) analyze the social optimum combination of patent length and renewal fee[15]. In their model, the firms' incentive to develop a high-quality inventions and the market competitiveness improve the social welfare whereas the monopoly power exacerbate the welfare. This tradeoff determines the socially optimal level of patent length and renewal fee. Our model focuses on

Table 1. The signs of each variable

| | Rate of eventual examination request | Rate of early examination request |
|---|---|---|
| $m$ : Period of examination request | − | + |
| $C$ : Examination request fee | − | − |
| $\gamma$ : Annual fee | − | − |
| $\mu$ : Average number of claims | + | + |

[13] We restrict our concern to the case that $C$ is sufficiently large and $d$ is sufficiently small.
[14] There are a lot of other papers which examines the influences of patent breadth and patent length on firms' innovative activities or social welfare, such as Gilbert and Shapiro (1990), Matutes, Regibeau and Rockett (1996) and O'Donoghue, Scotchmer and Thisse (1998).
[15] Cornelli and Schankerman insist that policy maker can maximize the social welfare by setting the renewal fee to make the firm choose the optimal patent length. Under this mechanism, the renewal fee can differ from firm to firm. Scotchmer suggests that firms reveal honestly their willingness to pay for the renewal fee deserving the cost under the effective renewal fee (or subsidy) structure when the value and the cost of innovation have a positive correlation. As a result, the social optimal patent length can be identical among firms.

the firm's behavior after the application. That is, our model ignores the firms' application behavior. Given the number of applications constant, firms' expected profit is larger as the period of examination request is longer. This is because the option value of holding the right of examination request is large when the allowable period is long. Moreover, long allowable period gives firms to assess the qualities of their applications so that firms save their examination request cost and annual fee. As for the consumer surplus, it is improved when the rate of examination request is low as long as the amount of published applications keeps constant. That is, the dead weight loss caused by firms' monopoly power becomes small as the number of patent decreases. Thus, the shorter period of examination request always worsens the social welfare in our theoretical framework.

In the actual modifications of fee structure in Japan, the JPO increases the examination request fee and decreases the annual patent fee. However, the expected total fee, which is the sum of the both expected fees, is kept almost constant as described later. We also find that this change increases the expected total cost of firms which have low-quality applications whereas it decreases for firms having high-quality applications. Therefore, these amendments have an effect of raising the average quality of the applications which are requested for examination with the expected profit of firms on average held constant. This improves the social welfare. In summary, we can see that these series of system reforms have an effect of balancing the both positive and negative impacts on social welfare.

However, if firms' application or R&D behavior and the information asymmetry are considered, the longer period of examination request can deteriorate social welfare. One reason is that leaving the applications unexamined restrains other firms' R&D and application behavior. This reduces the public knowledge which anyone can access. Moreover, when the quality of inventions is private information, the social welfare can decrease as a result of firms' opportunistic behaviors. In this case, firms have an incentive to file applications in order to block the R&D activities of other firms even if they know that the quality of their invention is quite low. Based on this perspective, longer period of examination request is not always desirable for social welfare[16]. We can, therefore, expect to exist the optimal allowable period. Similarly, the optimal level of examination request fee and annual fee would exist which decreases the requests for examination of relatively low-quality applications with ensuring the firms' incentive to invest in R&D. Thus the optimal revision of fee structures can alleviate the decrease in the average quality of applications which are examination requested by the shortening the allowable period. In this point of view, we can say that these system reforms are complementary policy means to improve the social welfare.

## 3. The Data

### 3.1 Data collection

We use the two data sources, patent data and business and financial account data, to analyze the impact of system reforms discussed above. Our patent data is obtained from IIP Patent Database (β version), we call as IIP-DB hereafter, which is provided by Institute of Intellectual Property. The account data is from NEEDS by Nihon Keizai Shimbun, Inc. IIP-DB was developed based on the patents filed with the Japan Patent Office, and consists of patent application file, registration file, applicant file, right holder

[16] If the applications obviously do not have patentability, it can be effective measures for third parties to request for examination for the concerned applications.

file, citation information file and inventor file. The last publication date of application included in this database is May 2007. All patent applications, in principle, are published in the public domain after 18 months from the filing date in Japan. We can, therefore, use the application data which filed by December 2005[17].

We restrict our analysis to the firms that have been publicly traded for the 1986-2005 periods and have been disclosed their R&D expenses during this whole period (827 firms). The patent data are matched to these firms, using firms' (applicants') harmonized names and addresses. As a result of this match, the final number of our sample becomes 726.

The purpose of this paper is to analyze the impact of the shortening of the period of examination request and the reforms of fee schedule. Our estimations are based on firm level and firm-IPC level monthly data. In the analysis of the impact of shortening of the allowable period, we use the rate of "eventual" request for examination. This rate is calculated as a ratio of the corresponding cumulative number of examination requests of a firm (or a firm-IPC) over the allowable period to the number of applications filed during certain one month. That is, this rate shows how many of the applications which were filed during certain one month are finally requested for examination.

By the end of September 2001, the examination request period is 7 years in Japan. Therefore, we cannot use the patent data which are filed between January 1999 and September 2001 since the examination request duration does not expire. After October 2001, the period of examination request is shortened to 3 years. This enables us to use the examination request data applied by the December 2002 because the last date of application is December 2005 in IIP-DB.

The Japan Patent Office raises the examination request fee and decreases the annual fee in April 2004. In the analysis of this impact the rate of eventual examination request cannot be calculated because of the data truncation. For this reason, we use the rate of "early" request for examination. This rate is calculated by dividing the number of examination requests which are done within one year from the date of applications by the number of applications. This enables us to use the patent data filed by December 2004.

### 3.2 Brief overview

We start with some descriptive information about our dataset. Figure 2 illustrates the average rate of eventual request for examination and the total number of applications of samples. We draw this figure based on patent level yearly data, though our estimations are based on firm level and firm-IPC level monthly data. Since examination request duration does not end for the applications filed between 1999 and 2001, and after 2003, we exclude these periods in this figure. Note that the number of applications and examination requests are fractionally counted by the number of applicants in this paper.

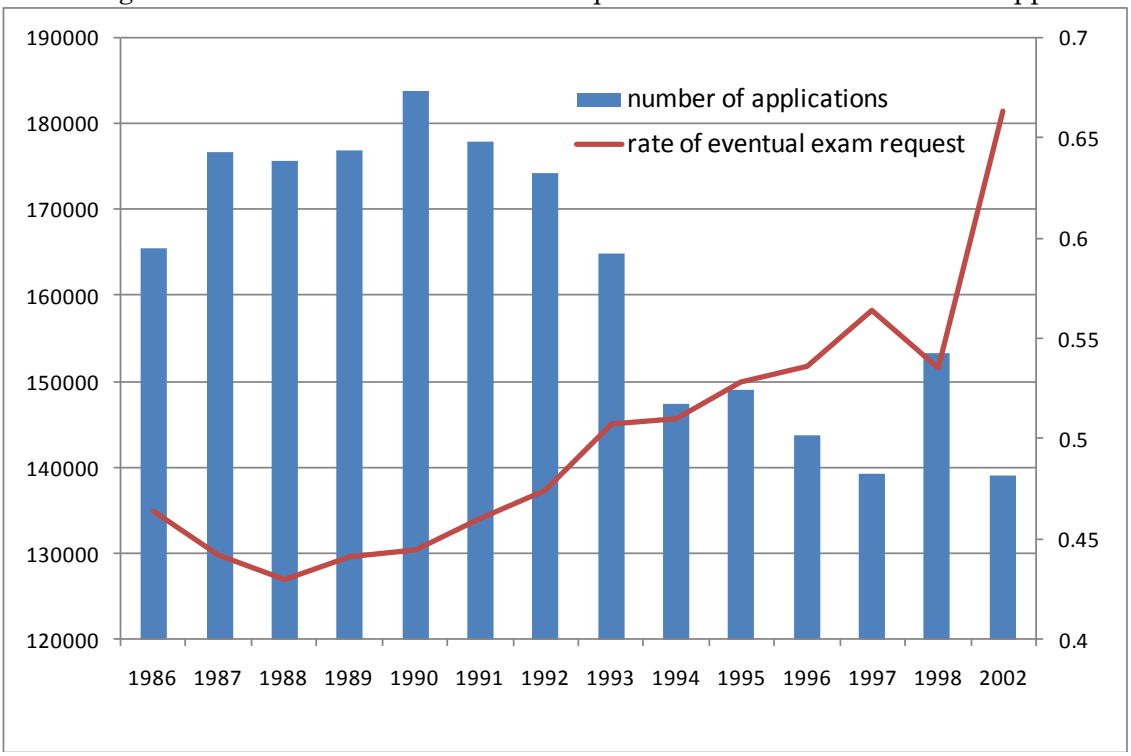
The rate of eventual examination request shows the gradual increase from 1988 and sharp rise from 1998 to 2002, whereas the number of applications shows a monotonous downward trend from 1990. We can consider this change as a result of the introduction of multiple-claim system in 1988 (the average number of claims increases from 2.2 in 1988 to 5.2 in 1998) and the shortening period of examination request in 2001.

Next, we see the changes in the average rate of early request for examination based on firm level monthly data in Figure 3. This rate is obtained by using the examination request within one year from the application date.

We add the average expected total fee of a firm per examination request, which is the sum of the average expected examination fee and average annual fee, in Figure 3. Note

[17] The detailed explanation of IIP-DB is given in Goto and Motohashi (2007).

Fig. 2 Average rate of eventual examination request and the total number of applications



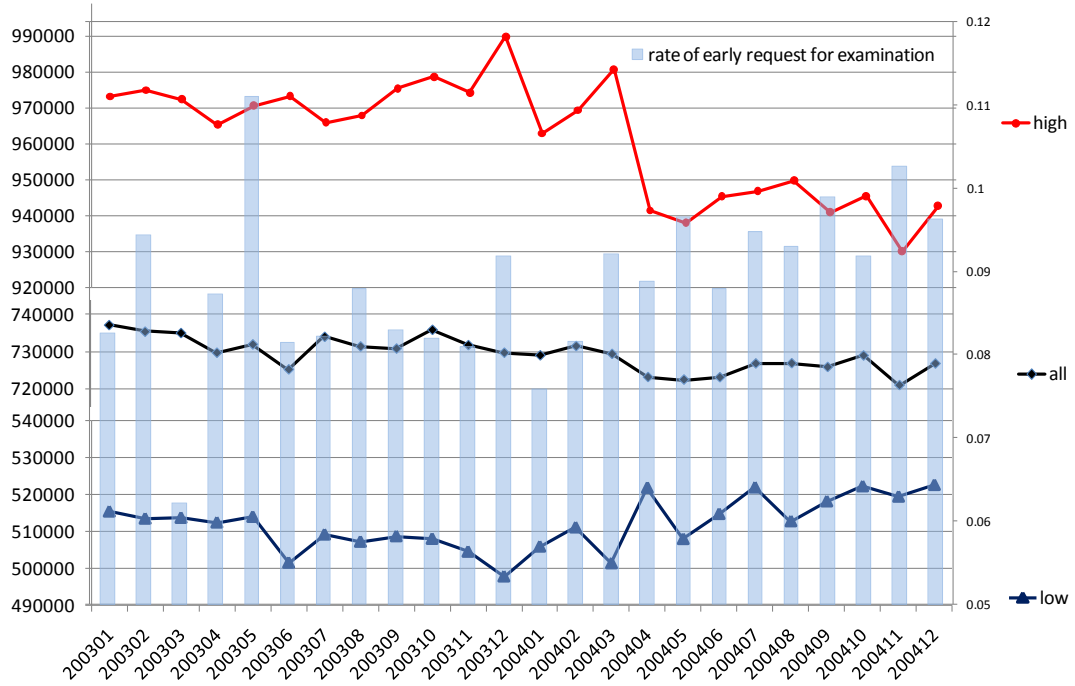

that the expected annual fee is the total amount of expected fee which firms have to pay to keep their patent in force during the expected renewal periods. Therefore, in calculation of this fee, we use an average grant rate which is the ratio of the number of patent registrations to the number of examination requests and an average patent renewal period of each firm between 1980 and 1984[18].

The main goal of the reforms of fee schedule is to reduce the total fee for relatively high-quality patents and to raise it for the relatively low-quality patents. This enhances the average quality of applications which are requested for examination with the average total fee held constant. To see this effect, we classify the sample into two groups by the average grant rate and the average renewal period. We define "low-quality group" as firms of which the grant rate is lower and the renewal periods are shorter than average. Similarly, "high-quality group" is the firms whose grant rate is higher and the renewal period is longer than average. We plot the expected total fee for each group in Figure 3.

As expected, we can see in this figure, the expected total fee of high-quality group decreases and that of low-quality increases after April 2004, holding the average total fee nearly constant. The rate of early examination request shows upward trend after the fee reforms in April 2004, though the average total fee remains almost unchanged. This gives some indication of the possibility that the effect of the decrease in annual fee is larger than that of the increase in the examination request fee. If the revision of fee schedule enhances the average quality, the rate of examination request would decrease. We, however, cannot confirm this effect in the figure. Using the quantitative method, we evaluate this impact more precisely in the next subsection.

[18] The patents which applied by the end of 1984 expire their patent term by the end of 2004.

Fig. 3 Expected total fee and the average rate of early examination request




### 3.2 Estimation framework

Fist, we estimate the following equation to analyze the effect of shortening the period of request for examination.

$$exrate_{i,j,t} = \beta_0 + \beta_1\, rdint_{i,t} + \beta_2\, lnasset_{i,t} + \beta_3\, ap_{i,j,t} + \beta_4\, lnipcap_{j,t} + \beta_5\, avclaim_{i,j,t} + \beta_6\, multiclaim_t + \beta_7\, shorten_t + \beta_8\, rlatter_{i,j,t} + \beta_9\, (shorten_t \times rlatter_{i,j,t}) + \omega_i\, \beta_{10} + \delta_t\, \beta_{11} + \varphi_{i,t}\, \beta_{12} + \theta_{i,j} + \varepsilon_{i,j,t} \quad .(23)$$

In this specification, $i$ denotes the firm, $j$ denotes the main IPC class of applications each firm files and $t$ denotes the monthly time. For our estimation based on the firm level data, we can ignore the subscript $j$ in the equation (23). Variable $\theta_{i,j}$ is a firm-IPC fixed effect. We introduce industry dummy $\omega_i$ and year dummy (not monthly) $\delta_t$. Moreover, we include industry-year dummy $\varphi_{i,t}$, which is $\omega_i$ times $\delta_t$, to control for unobserved common shocks and the appropriability in each industry and each year. The variable $\varepsilon_{i,j,t}$ is an error term. Note that we eliminate the data of which the period of examination request is unexpired in this estimation. It is between January 1999 and September 2001 during which the maximum delay a firm has for examination request was 7 years, and after January 2003.

The dependent variable $exrate_{i,j,t}$ is the rate of eventual request for examination of the applications which firm $i$ filed in IPC $j$ at time $t$.

The independent variable $rdint$ is the R&D intensity, which is the rate of R&D expenditure to the amount of tangible asset. We control firm size by logarithm of tangible asset ($lnasset$). We include the number of applications of each firm-IPC ($ap$), and the total number of applications in the relevant IPC class ($lnipcap$). The parameters we are inter-

ested in are from $\beta_5$ to $\beta_9$ in equation (23). The variable $avclaim$ is the average number of claims. We expect that the increase in $avclaim$ raise the examination request rate since the number of claims reflects the quality of the application. In addition, we examine the effect of the introduction of multiple-claim system by the dummy variable $multiclaim$, which takes 1 after January 1988. The dummy variable $shorten$, which takes 1 after October 2001, is created to capture the impact of shortening of the period of examination request. The variable $rlatter$ reflects the firm's uncertainty. It is calculated as the ratio of the number of examination requests in the latter half of allowable period to the number of those over the whole allowable period. We can consider $rlatter$ as the index of firms' propensity for delaying their decision-making. It is expected that the impact of shortening period of examination request is larger for the firms (or IPC classes) with high uncertainty. This is because the firms with high certainty already face a difficulty of assessing the availability of their applications within the allowable period. We capture this relation by including the cross term of $shorten$ and $rlatter$, $(shorten \times rlatter)$. The explanations of all variables used in the estimation are summarized in table A-2 in Appendix.

Second, we postulate the following specification to examine the effect of changes in the fee structure along with the shortening of allowable period.

$$\begin{aligned} oneexrate_{i,j,t} = {} & \beta_0 + \beta_1\, rdint_{i,t} + \beta_2\, lnasset_{i,t} + \beta_3\, ap_{i,j,t} + \beta_4\, lnipcap_{j,t} \\ & + \beta_5\, avclaim_{i,j,t} + \beta_6\, lntotalfee_{i,j,t} + \beta_7\, (LD_{i,j} \times lntotalfee_{i,j,t}) \\ & + \beta_8\, shorten_t + \omega_{\mathrm{i}}\, \beta_9 + \delta_t\, \beta_{10} + \varphi_{i,t}\, \beta_{11} + \theta_{i,j} + \varepsilon_{i,j,t} \ . \end{aligned} \tag{24}$$

The dependent variable $oneexrate_{i,j,t}$ is the rate of early request for examination which is calculated by using the examination request within one year from the application date. The merit of limiting the examination request data within one year is that we can extend the sample period to December 2004[19]. That is, we can use 8 periods after the reforms of fee structure in April 2004. Furthermore, we can examine whether the timing of examination request is accelerated since $oneexrate_{i,j,t}$ reflects how large part of applications are requested in the early stage of allowable period.

The independent variable $lntotalfee$ is the logarithm of expected total fee per examination request. This variable is calculated by using the average grant rate and average renewal length between 1980 and 1984[20]. We expect that the impact of the changes in fee schedule is larger for the firms having relatively low-quality applications. This is because the distribution of the patent quality is skewed to the left, and the policy reform increases the expected total fee for the low-quality patents whereas the one for high-quality patents decreases. In other words, the elasticity of examination request for the expected total fee is larger for the firms having low-quality applications. We confirm this effect with the cross term of the dummy variable $LD_{i,j}$ and the variable $lntotalfee_{i,j,t}$. The variable $LD_{i,j}$ takes 1 if the grant rate is lower than and the renewal periods are shorter than the average, which we define as "low-quality group" in Figure 3. It is expected that both $\beta_6$ and $\beta_7$ in equation (24) becomes negative.

The descriptive statistics of the variables used in our estimation are provided in Table A-3 (in Appendix).

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[19] Another merit is that we need not to eliminate the data between January 1999 and September 2001 and after January 2003 (till December 2004).

[20] Our sample is reduced to 659 firms since 67 firms have missing values in the period from 1980 to 1984.

### 3.3 Estimation results

Table 2 and Table 3 report the results of the OLS estimation of equation (23) based on firm level data and firm-IPC level data, respectively. We employ fixed effect estimation in model (1) and (2), and pooled estimation in model (3) and (4). The control variables *rdint*, *lnasset* and *ap* have negative effect in almost all cases on the rate of examination request. Thus, R&D intensity increases the number of applications more than that of examination requests and larger size of firms and applications result in the lower rate of examination request.

The impact of the introduction of multiple-claim system (*multiclaim*) has significantly negative effect in Table 2. This effect becomes insignificant in Table3, controlling the differences in IPC with the estimation based on firm-IPC level data. The variable *multiclaim* may reflect the first reaction of firms to the introduction of multiple-claim system, since the coefficient of dummy variable is evaluated at a specific point in time. On the other hand, the variable *avclaim* has a significant positive effect on the rate of examination request. Therefore, we find that the introduction of multiple-claim system does not have immediate effect, whereas it raises the examination request rate in the long run with the gradual increase in the average number of claims. That is, the long-term increase in the average quality of applications with the multiple claim system raises the rate of examination request over long periods. This is consistent with the theoretical proposition 4 (a) shown in previous section.

Table 2. Impact of shortening of the period (firm level)

| | *exrate* | | | |
|---|---|---|---|---|
| | fixed effect | | pooled | |
| | (1) | (2) | (3) | (4) |
| *rdint* | -0.122*** | -0.154*** | -0.132*** | -0.211*** |
| | (4.80) | (7.96) | (10.39) | (20.96) |
| *lnasset* | -0.038*** | -0.052*** | -0.036*** | -0.072*** |
| | (8.22) | (14.92) | (36.96) | (93.49) |
| *ap* | -0.331*** | -0.355*** | -0.187*** | -0.058*** |
| | (16.08) | (23.86) | (15.29) | (6.23) |
| *avclaim* | 0.004*** | 0.004*** | 0.006*** | 0.007*** |
| | (9.06) | (10.88) | (12.76) | (19.06) |
| *multiclaim* | -0.068*** | -0.048** | -0.051* | -0.067*** |
| | (2.67) | (2.45) | (1.85) | (3.03) |
| *shorten* | 0.157*** | 0.094*** | 0.139*** | 0.062*** |
| | (3.87) | (2.99) | (3.09) | (2.68) |
| *rlatter* | | -0.042*** | | -0.087*** |
| | | (17.74) | | (37.54) |
| *shorten*rlatter* | | 0.025*** | | 0.041*** |
| | | (2.90) | | (4.10) |
| *year*industry dummy* | yes | yes | yes | yes |
| Constant | 1.108*** | 1.339*** | 1.099*** | 1.630*** |
| | (24.33) | (38.54) | (50.32) | (92.33) |
| Observations | 81801 | 75850 | 81801 | 75850 |
| Number of firms | 726 | 725 | | |
| R-squared | 0.04 | 0.06 | 0.09 | 0.23 |

* significant at 10%; ** significant at 5%; *** significant at 1%
Absolute value of t statistics in parentheses

Table 3. Impact of shortening of the period (firm-IPC level)

| | *exrate* | | | |
|---|---|---|---|---|
| | fixed effect | | pooled | |
| | (1) | (2) | (3) | (4) |
| *rdint* | 0.027* | 0.004 | -0.082*** | -0.103*** |
| | (1.68) | (0.36) | (14.51) | (26.34) |
| *lnasset* | -0.076*** | -0.053*** | -0.047*** | -0.057*** |
| | (22.26) | (23.37) | (98.67) | (169.75) |
| *ap* | -1.866*** | -3.083*** | -0.187*** | -2.253*** |
| | (26.11) | (73.71) | (4.75) | (91.72) |
| *avclaim* | 0.008*** | 0.004*** | 0.009*** | 0.005*** |
| | (41.89) | (28.03) | (47.74) | (40.41) |
| *multiclaim* | -0.015 | -0.020 | -0.081*** | 0.007 |
| | (0.62) | (1.30) | (3.32) | (0.39) |
| *shorten* | 0.046* | 0.046* | 0.100*** | -0.014 |
| | (1.92) | (1.77) | (4.15) | (0.83) |
| *rlatter* | | -0.036*** | | -0.068*** |
| | | (33.78) | | (64.73) |
| *shorten*rlatter* | | 0.019*** | | 0.044*** |
| | | (4.79) | | (10.54) |
| *lnipcap* | -0.009*** | -0.056*** | -0.006*** | -0.034*** |
| | (3.78) | (34.78) | (12.69) | (97.20) |
| *year*industry dummy* | yes | yes | yes | yes |
| Constant | 1.482*** | 1.732*** | 1.266*** | 1.754*** |
| | (37.16) | (65.20) | (66.81) | (136.65) |
| Observations | 502689 | 373754 | 502708 | 373766 |
| Number of firm-IPCs | 25078 | 21548 | | |
| R-squared | 0.02 | 0.05 | 0.07 | 0.23 |

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

We are interested in the effect of the shortening of the period of examination request. The coefficient of the variable *shorten* shows the immediate impact of shortening period. It is significantly positive in model (1) and (3) in the both firm level and firm-IPC level estimation. Therefore, the shortening the allowable period raises the rate of eventual request for examination, as expected. This result supports the theoretical proposition 1 (a). We expect that the shortening of the period makes the firms with high certainty request for more examinations. In model (2) and (4), we include the cross term *shorten* × *rlatter* to examine this effect. The coefficient of this variable is positive and significant in both firm level and firm-IPC level estimation. Thus, we find that the positive impact of shortening of the period on the examination request rate is large especially for the firm (-IPC) facing high uncertainty.

Next, we show the results of OLS estimation of equation (24) in Table 4 and 5. Note that in this estimation, the dependent variable is the rate of early request for examination which firms requests within one year from the application date. This enables us to analyze the impact of changes in the fee structure on firms' early stage request behaviors. The models (1) and (2) show the results of fixed effect estimation, and models (3) and (4) show the results of pooled estimation. In this estimation, R&D intensity has a positive effect on the early request for examination. We can consider the applications which firms request examination in early stage as relatively high-quality applications. Thus, this result may capture the fact that the quality of applications of firms with high R&D inten-

sity is high. The coefficients of other control variables, *lnasset* and *ap*, have the same sign as the results of estimation of equation (23) though the significances are lower.

In Models (2) and (4), we include *multiclaim* and *shorten* to analyze the impact of multiple-claim system and the shortening of the period on firms' behavior of early stage examination requests. We confirm that the introduction of multiple-claim system has little effect, though the long-term increase in the average number of claims (*avclaim*) has strongly significant effect. This is consistent with proposition 4 (b). The variable *shorten* has positive coefficient. According to the theoretical proposition 1 (b), shortening the allowable period gives the firm an incentive to delay their decision in order to respond to the decrease in the amount of information. The empirical result does not support this proposition. We can attribute this seemingly inconsistent result to the fact that the theoretical model assumes that the same amount of additional information exists for the first and second period. In fact, the information available for the second period is much smaller after the reform, since the length of the second period is only 2 years, compared to 6 years before the reform. It is, therefore, more profitable for them to request for examination in early stage, since the additional information available is limited. The coefficient of the variable *lntotalfee* is significantly negative in all estimations. Thus, we find the decrease in the annual fee raises the rate of examination request in early stage. At the same time, the increase in the examination request fee decreases the examination request rate. This result can support the theoretical proposition 2 and 3. Our additional interest in this estimation is whether the impact of fee reform varies depending on the quality of applications. The impact of the increase in the examination request fee is near-

Table 4. Impact of fee structure reforms (firm level)

| | *oneexrate* | | | |
|---|---|---|---|---|
| | *fixed effect* | | *pooled* | |
| | (1) | (2) | (3) | (4) |
| *rdint* | 0.053*** | 0.053*** | 0.015** | 0.015** |
| | (4.53) | (4.52) | (2.14) | (2.12) |
| *lnasset* | -0.004 | -0.004 | -0.020*** | -0.020*** |
| | (1.63) | (1.64) | (34.32) | (34.32) |
| *ap* | -0.155*** | -0.155*** | 0.057*** | 0.057*** |
| | (12.54) | (12.51) | (7.30) | (7.32) |
| *avclaim* | 0.003*** | 0.003*** | 0.002*** | 0.002*** |
| | (2.99) | (2.99) | (6.38) | (6.37) |
| *multiclaim* | | -0.009 | | -0.014 |
| | | (0.52) | | (0.68) |
| *shorten* | | 0.021*** | | 0.022*** |
| | | (3.69) | | (3.45) |
| *lntotalfee* | -0.077*** | -0.078*** | -0.023*** | -0.023*** |
| | (3.28) | (3.29) | (8.33) | (8.32) |
| *LD*lntotalfee* | -0.018 | -0.017 | -0.001*** | -0.001*** |
| | (1.54) | (1.53) | (7.68) | (7.68) |
| *year*industry dummy* | yes | yes | yes | yes |
| Constant | 1.255*** | 1.257*** | 0.584*** | 0.584*** |
| | (4.02) | (4.02) | (14.75) | (14.75) |
| Observations | 106909 | 106909 | 106909 | 106909 |
| Number of firms | 659 | 659 | | |
| R-squared | 0.03 | 0.03 | 0.06 | 0.06 |

* significant at 10%; ** significant at 5%; *** significant at 1%
Absolute value of t statistics in parentheses

Table 5. Impact of fee structure reforms (firm-IPC level)

| | *oneexrate* | | | |
|---|---|---|---|---|
| | *fixed effect* | | *pooled* | |
| | (1) | (2) | (3) | (4) |
| *rdint* | 0.079*** | 0.079*** | 0.113*** | 0.113*** |
| | (17.86) | (17.86) | (51.38) | (51.38) |
| *lnasset* | -0.009*** | -0.009*** | -0.010*** | -0.010*** |
| | (7.02) | (7.02) | (49.87) | (49.86) |
| *ap* | -0.731*** | -0.731*** | 0.027 | 0.027 |
| | (24.13) | (24.11) | (1.51) | (1.53) |
| *avclaim* | 0.002*** | 0.002*** | 0.002*** | 0.002*** |
| | (6.61) | (6.62) | (20.12) | (20.10) |
| *multiclaim* | | -0.027** | | -0.026** |
| | | (2.23) | | (2.05) |
| *shorten* | | 0.020*** | | 0.020*** |
| | | (8.64) | | (8.28) |
| *lntotalfee* | -0.041*** | -0.041*** | -0.037*** | -0.037*** |
| | (6.49) | (6.52) | (26.10) | (26.11) |
| *LD*lntotalfee* | -0.037*** | -0.037*** | -0.003*** | -0.003*** |
| | (10.49) | (10.49) | (47.17) | (47.19) |
| *lnipcap* | -0.006*** | -0.006*** | -0.003*** | -0.003*** |
| | (6.20) | (5.87) | (13.01) | (12.95) |
| *year*industry dummy* | yes | yes | yes | yes |
| Constant | 0.865*** | 0.865*** | 0.693*** | 0.693*** |
| | (10.44) | (10.44) | (32.59) | (32.60) |
| Observations | 662775 | 662775 | 662797 | 662797 |
| Number of firm-IPCs | 26747 | 26747 | | |
| R-squared | 0.02 | 0.02 | 0.04 | 0.04 |

* significant at 10%; ** significant at 5%; *** significant at 1%
Absolute value of t statistics in parentheses

ly identical to all firms, whereas that of the decrease in the annual fee is larger for the firms with high-quality inventions. As a result, the reforms of fee schedule can be considered to increase the average quality of applications which are requested for examination. We examine this effect by introducing the cross term, $LD \times lntotalfee$ in our estimation. The expected sign of the coefficient of this variable is negative. As expected, the estimation results show the negative coefficient of $LD \times lntotalfee$, though the signi- ficance in the fixed effect estimation based on the firm level data is low.

The empirical results reported in this section are summarized as follows. The shortening of the period of examination request increases the rate of both eventual and early request for examination. This decreases the average quality of the applications for which examinations are requested. On the other hand, the revision of fee structure increases the rate of early examination request of firms with high-quality applications whereas it decreases that of firms with low-quality inventions. This increases the average quality of the applications which are requested for examination.

In this light, we can say that these policy reforms of Japanese examination request system are complementary with each other.

## 4. Conclusions

In recent years, the number of requests for examination has substantially increased whereas the number of applications has shown little increase in Japan. The Japan Patent

Office shortened the examination request period in order to decrease the stock of unexamined applications which have uncertain exclusive rights. Furthermore, the JPO amended the examination request fee and the annual fee to decrease the examination requests of low-quality applications. We theoretically and empirically evaluate the impact of these policy reforms.

The econometric estimation provides the evidence that the one of the causes of long-term increase in the rate of examination request is the gradual increase in the number of claims by the introduction of multiple-claim system. Our estimation also suggests that the shortening of the period of examination request gives firms an incentive to request for examinations of relatively low-quality applications. The impact of this reform is especially large for the firms with high uncertainty. Furthermore, the increase in the expected total fee decreases the rate of examination request. This has a larger impact on the firms which have relatively low-quality applications.

The shortening of the period of examination request is expected to restrain firms to leave the stock of applications with uncertain patentability. This can hinder rival firms' innovative activities. Theoretical analysis shows that shortening the allowable period increases the examination requests of relatively low-quality inventions and raises the examination request rate. This causes the decrease in the average quality of applications which are examination requested and increase the eventual grants of the patents, while reducing the expected profit from the patenting of the patentees. On the other hand, the increase in the examination request fee and the decrease in the annual fee have an effect to enhance the average quality of examination requested-applications. This revision offsets the impact of the shortening of the period by which the quality of patents decrease and the examination request rate rises. Based on this perspective, we can say that these two reforms in Japan complement each other.

## Appendix

Table A-1 Reforms of fee structure in April 2004

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Examination request fee | | | | | | | |
| On or before March 31, 2004 | ¥84,300 | + | ( ¥2,000 | × | number of claims | ) | |
| On or after April 1, 2004 | ¥168,600 | + | ( ¥4,000 | × | number of claims | ) | |
| Annual fee | | | | | | | |
| On or before March 31, 2004 | ¥13,000 | + | ( ¥1,100 | × | number of claims | ) | 1st to 3rd year |
| | ¥20,300 | + | ( ¥1,600 | × | number of claims | ) | 4th to 6th year |
| | ¥40,600 | + | ( ¥3,200 | × | number of claims | ) | 7th to 9th year |
| | ¥81,200 | + | ( ¥6,400 | × | number of claims | ) | 10th year or above |
| On or after April 1, 2004 | ¥2,600 | + | ( ¥200 | × | number of claims | ) | 1st to 3rd year |
| | ¥8,100 | + | ( ¥600 | × | number of claims | ) | 4th to 6th year |
| | ¥24,300 | + | ( ¥1,900 | × | number of claims | ) | 7th to 9th year |
| | ¥81,200 | + | ( ¥6,400 | × | number of claims | ) | 10th year or above |

Table A-2. Explanations of variables

| variable | explanation |
|---|---|
| *exrate* | rate of eventual request for examination |
| *oneexrate* | ratio of the number of examination requests within one year from the application date to the number of applications |
| *rdint* | rate of R&D expenses to tangible asset |
| *lnasset* | logarithm of tangible asset |
| *ap* | number of applications |
| *avclaim* | average number of claims |
| *multiclaim* | dummy variable which takes 1 after the introducion of multiple-claim system (in Jan. 1988) |
| *shorten* | dummy variable which takes 1 after the shortening period of request for examination (in Oct. 2001) |
| *rlatter* | rate of the number of examination requests in the latter half of allowable period to those over the whole allowable period |
| *shortrlatter* | cross term of *shorten* and *rlatter* |
| *lntotalfee* | logarithm of the sum of examination request fee and annual |
| *lnipcap* | logarithm of total number of applications in relevant IPC |
| *LD* | dummy variable which takes 1 if the grant rate is lower than and renewal period is shorter than average. |

Table. A-3. Descriptive statistics

| Analysis of shortening of the period (firm level) | | | | | |
|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Min | Max |
| *exrate* | 81837 | 0.684 | 0.316 | 0 | 1 |
| *rdint* | 81837 | 0.090 | 0.115 | 0.000 | 1.037 |
| *lnasset* | 81837 | 10.094 | 1.496 | 3.466 | 16.297 |
| *ap* | 81837 | 28.128 | 108.309 | 0.001 | 2673.928 |
| *avclaim* | 81801 | 3.451 | 2.743 | 1 | 82 |
| *multiclaim* | 81837 | 0.872 | 0.334 | 0 | 1 |
| *shorten* | 81837 | 0.093 | 0.291 | 0 | 1 |
| *rlatter* | 75878 | 0.687 | 0.384 | 0 | 1 |
| *shorten*rlatter* | 75878 | 0.081 | 0.262 | 0 | 1 |

| Analysis of shortening of the period (firm-IPC level) | | | | | |
|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Min | Max |
| *exrate* | 503063 | 0.585 | 0.421 | 0 | 1 |
| *rdint* | 503027 | 0.126 | 0.137 | 0.000 | 1.037 |
| *lnasset* | 503027 | 11.283 | 1.567 | 3.466 | 16.297 |
| *ap* | 503063 | 4.576 | 15.624 | 0.001 | 776.667 |
| *avclaim* | 502735 | 3.534 | 3.454 | 1 | 186 |
| *multiclaim* | 503063 | 0.877 | 0.329 | 0 | 1 |
| *shorten* | 503063 | 0.089 | 0.285 | 0 | 1 |
| *rlatter* | 374055 | 0.725 | 0.412 | 0 | 1 |
| *shorten*rlatter* | 374055 | 0.085 | 0.274 | 0 | 1 |
| *lnipcap* | 503063 | 5.735 | 1.230 | 0.223 | 8.455 |

| Analysis of changes in fee structures (firm level) | | | | | |
|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Min | Max |
| *oneexrate* | 110583 | 0.081 | 0.221 | 0 | 1 |
| *rdint* | 110583 | 0.093 | 0.124 | 0.000 | 2.739 |
| *lnasset* | 110583 | 10.115 | 1.486 | 3.466 | 16.297 |
| *ap* | 110583 | 26.855 | 101.625 | 0.001 | 2673.928 |
| *avclaim* | 110028 | 4.114 | 3.162 | 1 | 82 |
| *multiclaim* | 110583 | 0.905 | 0.293 | 0 | 1 |
| *shorten* | 110583 | 0.176 | 0.381 | 0 | 1 |
| *lntotalfee* | 106909 | 13.444 | 0.344 | 11.721 | 15.429 |
| *LD* | 107468 | 0.228 | 0.420 | 0 | 1 |

| Analysis of changes in fee structures (firm-IPC level) | | | | | |
|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Min | Max |
| *oneexrate* | 673186 | 0.057 | 0.210 | 0 | 1 |
| *rdint* | 673136 | 0.130 | 0.151 | 0 | 2.739 |
| *lnasset* | 673136 | 11.272 | 1.550 | 3.466 | 16.297 |
| *ap* | 673186 | 4.411 | 14.792 | 0.001 | 776.667 |
| *avclaim* | 667873 | 4.250 | 4.027 | 1 | 186 |
| *multiclaim* | 673186 | 0.908 | 0.289 | 0 | 1 |
| *shorten* | 673186 | 0.164 | 0.370 | 0 | 1 |
| *lntotalfee* | 662797 | 13.414 | 0.301 | 11.721 | 15.991 |
| *LD* | 668104 | 0.266 | 0.442 | 0 | 1 |
| *lnipcap* | 673186 | 5.758 | 1.240 | 0.134 | 8.455 |

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