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An Economic Analysis of Deferred Examination System: Evidence from Policy Reforms in Japan†

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Abstract

We investigate how a deferred patent examination system promotes ex-ante screening of patent applications, which reduces both the number of granted patents and the use of economic resources for examinations, without reducing the return from R&D. Based on a real option theory, we develop a model of examination request behaviors. Exploiting the responses of Japanese firms to recent policy reform, we find that the shortening of the allowable period for an examination request significantly increases both eventual and early requests, controlling for the blocking use of a pending patent application. This effect is stronger in technology areas with higher uncertainty. These results support the importance of uncertainty for an applicant and of ex-ante screening.

JEL classification numbers: C41, L21, O34

Keywords: patent, examination, option value, fee structure, R&D

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1. Introduction

Unlike the United States Patent and Trademark Office (USPTO), the Japan Patent Office (JPO) and the European Patent Office (EPO) only examine patent applications after receiving formal examination requests from applicants. In Japan, if such a request is not received within three years of the date of the application, the application is deemed to be withdrawn. Under the first-to-file system, an inventor has an incentive to file his patent application as soon as possible. Therefore, inventors apply for a patent on even such an invention that has significant uncertainty in patentability and in the probability of its commercialization. Examining all applications has two important economic costs. First, it increases significantly the number of patent grants. Such grants constrain third parties without increasing the ex-ante profit of an applicant from its R&D. Second, economic resources are used for more examinations. Under the recent environment of "patent explosions," increasing patent applications place strains on the patent office, which can result in longer pendency periods and a higher probability of mistakes in grant decisions.

A deferred examination or an examination request system provides an important mechanism reducing these social costs. It does so by providing patent applicants with more time to screen their inventions before requesting examinations. Such an arrangement is likely to be especially important when uncertainty in commercialization is high. In this regard, what ultimately matters for a firm in seeking patent protection is not the technical quality of an invention per se but the value of patenting such invention, which depends on a number of factors, including the availability of complementary assets. For many inventions, the resolution of uncertainty in the value of patenting can take a long time.[1] However, the examination request system may also induce applicants to use pending applications, even if they do not meet patentability standards, to block third-party innovative investment. An examination request by a third party may not adequately prevent this blocking use of pending applications.[2]

Thus, a trade off may well exist in introducing or designing a deferred examination system: a longer examination request period enhances the ex-ante "screening effect" of examinations, thereby decreasing the number of patent examinations (as well as patent grants) and reducing the burden on a patent office, while increasing the "blocking effect" of pending applications. Perhaps reflecting this tradeoff, not all countries have adopted an examination request system, and the allowable period for examination requests varies

[1] A telling example is a drug patent. In the pharmaceutical industry, firms often need more than ten years after filing a patent to introduce a new drug into the market. Uncertainty is gradually reduced through laboratory testing, preclinical testing, and clinical trials.

[2] A third party can request an examination and will do so if it benefits from an early clarification of the patentability of pending applications are greater than the cost of requesting an examination. However, the individual benefit for a third party may not be large, when the possibility of being blocked is relatively small, the cost of developing a circumventing invention is small, or the invention may not immediately be used. Still, the collective benefit for third parties from early clarification can be significant. However, even if that is the case, a free rider problem among third parties for examination requests makes it difficult to realize such aggregate benefits.

among patent offices. In particular, all patent applications are automatically examined at the USPTO, although there have been debates on whether the U.S. should also introduce a deferred examination system.[3] Moreover, concern over pending applications led in 2001 to the reduction of the allowable period for examination requests from seven to three years in Japan.

A comprehensive economic analysis of the deferred examination system does not exist. This paper provides both a theoretical model for such a system, based on a real option theory and an empirical validation of the importance of the ex-ante screening effect predicted by the model, by examining the responses of Japanese firms to this policy change. Our theoretical model explains why applicants might delay examination requests in an environment in which new information arrives in the future, with particular focus on the importance of the screening effect. We take into account the blocking value of a pending application, although we do not model the interactions between firms. We analytically solve the model and provide comparative statics results on how the maximum length of the pending period affects the volume of examination requests and their timing. In particular, we show theoretically that examination requests increase

[3] On January 28, 2009 the USPTO solicited public comments on whether a deferred examination procedure should be introduced in the US.

with the reduction of the maximum pending period more in sectors where ex-ante screening is important and that ultimate examination requests are not affected by the blocking value of pending applications.

Our empirical analysis seeks to validate these theoretical results. The reduction of the allowable period for Japanese examination requests from seven to three years in 2001 provides us with a unique exogenous shock, which affects the amount of information that an applicant can use in making an examination request decision. Utilizing the panel data at the monthly and individual patent application levels, we can control for demand, technology, and patent system changes over time, when we identify the effects of the policy change. We can also control for the importance of blocking motivations of pending and granted patents in our estimations.

The rest of the paper is organized as follows. Section 2 presents a survey of related studies. In Section 3, we provide an option-based theoretical model and develop hypotheses grounded on comparative statics results. Section 4 describes the dataset and provides the empirical results. Section 5 concludes the paper, discussing the policy implications of our analysis.

2. Related Studies

A patent renewal decision is similar to that of postponing a patent examination request, in the sense that both involve the evaluation of option values. Our research addresses related but distinct questions, compared with the existing studies on patent renewals. Pakes (1986) is a pioneering paper, which develops the option theory of patents and assesses the value of patent protection from patent renewal data. In his model, the underlying stochastic process of patent renewal incorporates the possibility of discovering the zero value of maintaining a patent for an invention, the decay of the current return, and some probability of innovation (a multiplicative increase of the return). He estimates the parameters characterizing the above stochastic process by using historical patent renewal data in three patent offices (France, Germany, and United Kingdom).[4] Although his model is very general, the research focuses on the calibration of the model to the patent renewal schedules in order to derive the statistical distribution of patent values. Furthermore, in his paper, analytical solutions are not provided; thus, comparative statics are not available. Our research addresses ex-ante screening of patent examination, which can avoid the tradeoff between the number of granted patents and the profit from

[4] Using Pakes' approach, Deng (2007) analyzes the changes in the value of patents after the establishment of the EPO. She suggests that the harmonization of the patenting process in the EPO reduced the differences in the patent value among these countries, while the changes in patent length and renewal fees had only modest effects on patent value.

R&D and it can reduce the use of resources for examinations. We provide analytical results on the effect of shorter deferral period on examination requests from comparative statics and their empirical assessments.

Cornelli and Schankerman (1999) and Scotchmer (1999) focus on renewal fees as instruments for socially optimal patent protection.[5] They show that policy makers can maximize social welfare by setting renewal fees to make firms choose optimal patent lengths. Scotchmer suggests that firms honestly reveal their willingness to pay under the effective renewal fee (or subsidy) structure, when the value and the cost of innovation have positive correlations. In both analyses, a firm knows the private value and the cost of an invention, while the government does not, and the renewal fee schedule works as a revelation mechanism. In comparison, this paper focuses on the uncertainty for the firm. In our model, the firm itself does not know the value of patent protection for its invention so that the pendency period before the examination request allows the firm to accumulate information for its decision on patenting. The policy issue addressed is also different: the optimal length of patent protection vs. ex-ante screening for patent examination.

Regibeau and Rockett (2010) analyze the relationship between the examination

[5] There are seminal papers that examine the influence of patent breadth and patent length on the innovative activities of firms or social welfare, such as Gilbert and Shapiro (1990), Matutes et al. (1996), and O'Donoghue et al. (1998).

duration of the patent office and the importance of patents. They assume that the duration of a patent examination is endogenous to the effort of the applicant and that its accuracy improves as technology matures. They show that the more important inventions are examined earlier and that over time the examination duration decreases for good applications and increases for bad applications, all things being equal. Their framework includes an information asymmetry between applicant and examiner regarding the patentability of the application. The applicant changes the amount of the effort that he exerts in the examination process according to the importance of applications so that a patent is granted earlier to its more important invention. Our model focuses on the applicant's learning process of the application value and analyses the screening effect of the examination request system, while we do not consider the examiner's learning.

Harhoff and Wagner (2009) also find that potentially valuable patents will be granted earlier and that a withdrawal of such patents will be delayed. Further, they indicate that applications with complex examination tasks (a large number of references, claims, and so on) are withdrawn earlier by applicants during the examination process. Moreover, the applicant becomes more cooperative in this process when the value of an invention is high.

A few studies investigate the applicant's behavior for delaying an examination request.[6] Using a matched sample of patent applications filed simultaneously in four patent offices, Palangkaraya et al. (2008) show that the timing of examination requests for the same patent application varies among countries because of differences in the allowable periods. They argue that applicants may use their private knowledge about the patentability of their inventions to constrain the R&D activities of rival firms by delaying the decision on the examination request. Henkel and Jell (2010) analyze the applicant's incentive to defer the examination process, focusing on the request behavior of German patent applicants. Based on interviews and surveys of inventors, they find that both the motivations of "gaining time for evaluation" and "creating insecurity" are significantly negatively correlated with early examination requests.[7] Although these studies provide important insights, they do not offer an underlying theoretical model or an empirical verification of the importance of uncertainty, based on an exogenous shock. Our model provides such an analysis, while taking into account the blocking use of a pending application.

[6] Sampat (2011) suggests that the applicants have an inventive to contribute more to the prior art search when the inventions are more important for them.
[7] Koenen and Peitz (2011) also emphasize the importance of a blocking motivation for the applicants (creating insecurity).

3. A Theoretical Model

3.1 Framework

We use a simple two-stage model ($t = 1, 2$), where a firm has two chances to decide whether it requests an examination for its patent application.[8] The first chance is the date of the patent application ($t = 1$), and the second chance is the end of the allowable period of the examination request ($t = 2$). In this paper, we ignore examination requests by third parties, even though they are possible under the Japanese or European patent laws, since we focus on the ex-ante screening of an applicant.

We assume that an applicant does not know the true (private) economic value of patenting his application i, $\hat{q}_i$. The true value $\hat{q}_i$ consists of two parts: the part known ex-ante (we interpret this as the quality of technology and denote by μ_i) and the part unknown ex-ante (we interpret this as the market size and denote by λ_i). That is, an applicant knows its technological quality but not its future market size. We assume that variable λ_i is uniformly distributed over the range $[-1, 1]$ with $E[\lambda_i] = 0$, without a loss of generality. We can write the true economic value of patenting an application as

$$\hat{q}_i = \mu_i + \lambda_i. \tag{1}$$

[8] The option right, such as a patent renewal right and the right for an examination request, is an American option that can be exercised at the any time before the expiration date. Unlike European option, it is quite difficult to solve the equilibrium values of American option in general form, and thus, past studies have resorted to a simulation analysis. Instead of a simulation analysis, we will develop a simple two-stage model so that we can conduct a comparative statistics.

In each stage, the firm decides whether to request an examination, based on the subjective value of patenting its application (denoted by $q_{i,t}$), without knowing the application's true value $\hat{q}_i$. At the date of the patent application, when the firm has no information about the market size, the expected value of patenting the application of the firm is given by $q_{i,1} = \mu_i$.

By delaying the decision of the examination request, the firm may obtain a signal from nature. The signal in the second stage can narrow the gap between the firm's initial expectation regarding the subjective patenting value μ_i and the true value $\hat{q}_i$ so that the firm revises its expectation. We write this signal in the second stage as follows:

$$s_i = \left(\hat{q}_i - q_{i,1}\right) + \delta_i = \lambda_i + \delta_i, \tag{2}$$

where δ_i represents a noise with $\mathrm{E}[\delta_i] = 0$.

A firm can only estimate the amount of the necessary revision of its expectation, since it cannot directly observe the exact correction $\left(\hat{q}_i - q_{i,1}\right)$ to be made. The efficient estimator of the optimal revision ε_i is given by

$$\varepsilon_i = m \cdot s_i, \tag{3}$$

where m measures the preciseness of the signal's information. It is given as the ratio of the variance of a true signal $(\hat{q}_i - q_{i,1})$ to the variance of noise δ_i, that is, $m = 1/\{1 +$

$var(\delta_i)/var(\lambda_i)\}$. Variable m depends on the allowable period of the examination request (L), since the available information increases with the increase in the period. Furthermore, the amount of information available during the pendency period differs depending on the sector-specific uncertainty (denoted by η). Therefore, we can write m as $m(L,\eta)$. We assume that $m_L \geq 0$ and $m_\eta \leq 0$, where m_j is the derivative of m with respect to $j = L, \eta$. We also assume that the marginal effects of L and η are independent: $m_{L\eta} = m_{\eta L} = 0$.

The subjective value of the firm's application i in each stage $q_{i,t}$ is represented as follows:

$$q_{i,1} = \mu_i \tag{4}$$

$$q_{i,2} = q_{i,1} + \varepsilon_i = \mu_i + m\{(\hat{q}_i - \mu_i) + \delta_i\} = m\hat{q}_i + (1-m)\mu_i + m\delta_i \tag{5}$$

Let us denote the maximum length of the patent protection as T. Our model analyzes the firm's behavior after its filing of an application. Therefore, we take the firm's patent application behavior as exogenous. If the firm requests an examination in the first stage, it can enjoy patent protection for T periods. However, by delaying the decision to the next stage, the firm can acquire additional information about market size. Considering this tradeoff, the firm decides whether it will exercise the examination request option. In the case where the firm requests an examination in the second stage, the length of the patent protection becomes $(T - L)$.[9]

Let C and $R_{i,t}$ denote the examination request fee to be paid at the beginning of the stage and the expected present value of the patent protection when the patent is granted at period t, respectively. In this model, we assume that the discount factor is equal to one.

The firm can obtain the blocking value from a pending application denoted by B_i (net present value) in the first period by delaying its decision, although in the second stage the blocking value of a pending application disappears because of the clarification of right. Naturally, the exclusive power is larger when the invention is protected by the patent ($R_{i,1} > B_i$). Note that the value of patent protection includes the blocking value of a granted patent, while B_i measures only the blocking value of a pending application.

The blocking value of a pending application increases with the length of the pending period, but it is assumed to be independent of $q_{i,t}$. For simplicity, we assume that the benefit of pending application B_i increases proportionally with the length of the pending period.

[9] In a model with continuous time, the length of patent protection depends on the waiting period of an applicant. Specifically, an applicant decides on the optimal delay by considering what amount of information should be accumulated. In this continuous time setting, the essence of the applicant's decision under the examination request system remains the tradeoff between the length of effective patent protection and the amount of information to save the cost of patenting. Our two-period model is simple but is meant to capture this essential tradeoff for the applicant.

$$B_i = b_i L, \tag{6}$$

where b_i is a constant value.

For simplification, we assume that all applications that request examination are granted.[10] Our model also assumes that the value of lapsed applications is zero. Then, the value of application i in stage t, $V_{i,t}$, is given by the following equation:

$$V_{i,t} = \begin{cases} max\{R_{i,1} - C,\ B_i + V_{i,2}\} & if \quad t = 1 \\ max\{R_{i,2} - C,\ 0\} & if \quad t = 2 \end{cases} . \tag{7}$$

Equation (7) implies that the present value of the right of an examination request becomes whichever is greater: the expected profit of requesting an examination in stage 1 or the expected present value of the right in stage 2, with delaying the decision. The expected present value of a granted patent at the second stage $R_{i,2}$ becomes smaller as the period L becomes longer, since the patent protection period is $(T - L)$.We can define $R_{i,t}$ by the following equation, using the subjective value of application $q_{i,t}$ and the renewal fee γ:

$$R_{i,t}\big(q_{i,t}, (t-1)L, \gamma\big) \equiv \{T - (t-1)L\}\big(q_{i,t} - \gamma\big),\ \ t = 1, 2. \tag{8}$$

3.2 Solution

[10] The result does not change if we assume that the probability of a grant is an exogenous variable. We can also consider the case in which the probability of a grant is a function of the technological quality, i.e., $p(\mu_i)$. In this case, the main results would not change, since the value of requesting an examination is an increasing function of the grant rate, although the calculation becomes quite complicated.

To solve the model, we can write firm i's decision-making problem in stage t as the following equations, where $X_{i,t}=1$ means that firm i requests an examination and $X_{i,t}=0$ means that the firm does not request it.

$$X_{i,2}=\begin{cases}1 & if \quad (T-L)\left(q_{i,2}-\gamma\right)-C\geq 0\\ 0 & otherwise\end{cases}. \tag{9}$$

$$X_{i,1}=\begin{cases}1 & if \quad T\left(q_{i,1}-\gamma\right)-C\geq b_iL+V_{i,2}\\ 0 & otherwise\end{cases}. \tag{10}$$

Given μ_i, let us denote the critical value of λ_i satisfying $(T-L)\left(q_{i,2}-\gamma\right)-C=0$ in equation (9) by $\underline{\lambda}_i$. Then, the applications whose signal is sufficiently large ($\lambda_i\geq\underline{\lambda}_i$) are, on average, the subjects of an examination in the second stage. Similarly, given the critical value of the initial expectation $\underline{\mu_i}$ satisfying $T\left(q_{i,1}-\gamma\right)-C=bL+V_{i,2}$, the applications with technological quality higher than $\underline{\mu_i}$ ($\mu_i\geq\underline{\mu_i}$), are, on average, the subjects of an examination in the first stage (we formally show later that the applicant requests early examination, or $X_{i,1}=1$ in equation (10) is more likely to be satisfied, if the invention quality is above this line, as Lemma 1 in the next section). We can define these critical values ($\underline{\lambda}_i$ and $\underline{\mu_i}$) by the following equations.

$$(T-L)(\mu_i+m\underline{\lambda}_i-\gamma)=C, \tag{11}$$

$$T(\underline{\mu}_i-\gamma)-C=b_iL+\frac{1-\underline{\lambda}_i(\underline{\mu}_i)}{2}\left[(T-L)(\underline{\mu}_i+m\frac{1+\underline{\lambda}_i(\underline{\mu}_i)}{2}-\gamma)-C\right]. \tag{12}$$

In equation (12), $\frac{1-\underline{\lambda}_i(\underline{\mu}_i)}{2}$ indicates the probability that the applicant will request an examination in the second stage ($\Pr[\lambda_i \geq \underline{\lambda}_i]$). The square bracket at the right hand side of equation (12) is the conditional expected value of patenting the application: $(T - L)(E\left[q_{i,2} \middle| \lambda_i \geq \underline{\lambda}_i\right] - \gamma) - C$. Note that the conditional market size of the applied patent is given by $\frac{1+\underline{\lambda}_i}{2}$.

We assume that the applicant always requests an examination, if he cannot use any information ($m = 0$).

Assumption 1: $(T - L)(\mu_i - \gamma) - C > 0$ or, equivalently, $\underline{\lambda}_i < 0$, for any μ_i under consideration.

The two conditions of this assumption are equivalent from equation (11). The condition $\underline{\lambda}_i < 0$ indicates that the firm will request an examination, even if it receives some negative news on the size of the market in the second period.

The parameter restrictions imposed by Assumption 1 is represented in Figure 1. In this figure a negatively sloped line (hereafter called "market size threshold") represents equation (11) and the horizontal line with $\underline{\mu}_i$ (hereafter called "invention quality threshold") represents the solution of equation (12). Note that the applicant who made an early examination request cannot withdraw its request, even if he receives the negative signal on the market size in the second stage. The area above this invention quality threshold represents the set of the combinations of the two parameters, for which early examination requests are made. The area between the invention quality threshold and the market size threshold represents the set of the combinations of the two parameters for which late examination requests are made. The aggregation of these two areas represents the parameter combinations where the eventual examination requests are made.

[Place Figure 1 approximately here]

3.3 Comparative Statics

In this section, we analyze the impacts of the changes in the exogenous variables on the critical levels $\underline{\lambda}_i$ and $\underline{\mu}_i$ and thereby on the examination request profile. First, we show the effects of shortening the allowable period of the examination request on the rate of eventual examination requests. Thus, we examine the effects of the decrease of L on $\underline{\lambda}_i$ for a given μ_i.

$$-\frac{\partial \underline{\lambda}_i}{\partial L} = -\frac{(\mu_i-\gamma)m(T-L)-\{C-(T-L)(\mu_i-\gamma)\}\{m_L(T-L)-m\}}{\{(T-L)m\}^2} = -\frac{(C/(T-L))-m_L(T-L)\underline{\lambda}_i}{(T-L)m} < 0, \qquad (13)$$

The reduction of the allowable period has two positive effects on the rate of eventual examination requests. The first effect is derived from increasing the period of patent protection: $\mu_i + m\underline{\lambda}_i - \gamma = C/(T-L)$. The second effect is generated from the reduction of the available information: $-m_L(T-L)\underline{\lambda}_i$; it is also positive if the expected patenting value is sufficiently large (Assumption 1 holds), so that $\underline{\lambda}_i < 0$. Longer patent protection increases the value of patenting, and the reduction of the available information makes it more difficult to screen out low-quality applications (that is, the applications, which have only low patenting values) for examination. As shown in Figure 1, the negatively sloped market threshold line has a lower intersect with the vertical axis and also rotates in the direction of left-hand side with the reduction of L. Therefore, shorter allowable period results in the increase of the area where the eventual examination requests are made.

Note that the blocking motivation of a pending application (denoted by b_i) does not affect the firm's behavior with regard to eventual examination requests, and thus, its variation does not alter the effects of the above policy changes on the rate of eventual examination requests.

Proposition 1 (eventual examination request)

(a) The reduction of an allowable period for examination requests decreases the average quality of applications requested for examination ($-\partial\underline{\lambda}_i/\partial L < 0$ for any given μ_i), which

implies the increases of eventual examination requests.

(b) The blocking motivation of a pending application does not affect the firm's behavior with regard to eventual examination requests

Second, we examine whether the impact of the shortening of the period of examination request is affected by the degree of sector specific uncertainty (η), under Assumption 1.

$$-\frac{\partial^2 \underline{\lambda_i}}{\partial L\, \partial \eta} = m_\eta \frac{(\mathrm{C}/(\mathrm{T-L}))-2m_L(T-L)\underline{\lambda_i}}{(T-L)m^2} < 0. \quad (14)$$

Equation (14) suggests that the impact of the policy change increases with the degree of uncertainty under Assumption 1. In the technology field, where the degree of uncertainty is high, the decrease in the amount of information makes it more difficult for the firm to assess the value of its application during the allowable period. This increases the firm's incentive to request an examination. Again, the blocking value of a pending application does not affect the magnitude of the impact of policy reform on eventual examination requests.

Proposition 2 (uncertainty)

A higher degree of uncertainty increases the effect of the shortening of the allowable *period on eventual examination requests.*

If Assumption 1 does not hold, and $\underline{\lambda}_i > 0$ for any μ_i under consideration, a firm will not request an examination, unless it receives good news on the market size. In such case, the reduction of information tends to increase the threshold of requesting an examination—that is, $-m_L(T-L)\underline{\lambda}_i$ is negative. If this effect is sufficiently strong, the shortening of the allowable period decreases eventual examination requests and such an effect can be larger in the sector with high uncertainty, contrary to the prediction of Proposition 2.

Last, we analyze the impacts of policy changes on the rate of early examination requests. Note that the value of an early examination request is not directly affected by the length of the allowable period, since the firm's decision is simultaneously made with the patent application. However, the changes of the option value of an examination request affect the firm's decision in the early stage. Denoting the right hand side of equation (12) by RHS, which is a function of $\underline{\mu}_i$, $\underline{\lambda}_i(\underline{\mu}_i, L)$ and L, and the left hand side by LHS, which is a function of only $\underline{\mu}_i$, we have the following relation.

$$-\frac{\partial \underline{\mu}_i}{\partial L} = \frac{\frac{\partial LHS}{\partial L} - \frac{\partial RHS}{\partial L}}{\frac{\partial LHS}{\partial \underline{\mu}_i} - \frac{\partial RHS}{\partial \underline{\mu}_i}} . \tag{15}$$

First, we show that the denominator of the equation (15) is positive. This is because

$$\frac{\partial LHS}{\partial \underline{\mu}_i} = T > \frac{\partial RHS}{\partial \underline{\mu}_i} = \frac{1}{2}(T-L)(1-\underline{\lambda}_i),\ \forall \underline{\lambda}_i \in [-1,1].^{11} \tag{16}$$

This result implies that the value of an early examination request increases more rapidly with the technical quality of an invention than with that of postponing the request. Thus, we have the following lemma:

Lemma 1

A firm requests for an early examination for high quality inventions.

Furthermore, the sign of equation (15) ($-\frac{\partial \underline{\mu}_i}{\partial L}$) depends only on that of $\frac{\partial RHS}{\partial L}$, since $\frac{\partial LHS}{\partial L} = 0$.

$$-\frac{\partial RHS}{\partial L} = \frac{1}{2}\frac{\partial \underline{\lambda}_i}{\partial L}[(T-L)(\underline{\mu}_i + m\frac{1+\underline{\lambda}_i}{2} - \gamma) - C]$$

$$+\frac{1-\underline{\lambda}_i}{2}[(\underline{\mu}_i + m\frac{1+\underline{\lambda}_i}{2} - \gamma) - (T-L)(m_L\frac{1+\underline{\lambda}_i}{2} + \frac{m}{2}\frac{\partial \underline{\lambda}_i}{\partial L})] - b_i$$

$$= \frac{1-\underline{\lambda}_i}{2}[(\underline{\mu}_i + m\frac{1+\underline{\lambda}_i}{2} - \gamma) - (T-L)m_L\frac{1+\underline{\lambda}_i}{2}] - b_i, \tag{17}$$

since the effect of the marginal change of $\underline{\lambda}_i$ has no effect from equation (11).[12] Thus, the effects of marginal decrease of L on the expected option value of postponing the

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[11] $\frac{\partial RHS}{\partial \underline{\mu}_i} = \frac{1-\underline{\lambda}_i}{2}(T-L) + \frac{1}{2m}\{(T-L)(\underline{\mu}_i + m\frac{1+\underline{\lambda}_i}{2} - \gamma) - C\} - \frac{1-\underline{\lambda}_i}{2}(T-L)(-\frac{1}{2})$. Substituting $(T-L)(\underline{\mu}_i - \gamma) - C = -(T-L)m\underline{\lambda}_i$ from equation (11), we have $\frac{\partial RHS}{\partial \underline{\mu}_i} = \frac{1}{2}(T-L)(1-\underline{\lambda}_i)$.

[12] $\frac{1}{2}\frac{\partial \underline{\lambda}_i}{\partial L}[(T-L)(\underline{\mu}_i + m\frac{1+\underline{\lambda}_i}{2} - \gamma) - C] + \frac{1-\underline{\lambda}_i}{2}[-(T-L)\frac{m}{2}\frac{\partial \underline{\lambda}_i}{\partial L}]$ can be rewritten as $\frac{1}{2}\frac{\partial \underline{\lambda}_i}{\partial L}(T-L)\left(\mu_i + m\underline{\lambda}_i - \gamma\right) - C$, which is 0 from equation (11).

examination request to the second stage (RHS) can be decomposed into three effects. The first effect (negative) stems from the decrease in the amount of information available for the applicant, expressed by the second term in the bracket: $-(T-L)m_L\frac{1+\lambda_i}{2} \leq 0$. The applicant discounts more significantly the news on the market size, which is on the average positive. The second effect (negative) is from the decrease in the blocking value of a pending patent application, represented as the last term: $-b_i < 0$. The last effect (positive) is derived from the increase in the value of protection of the invention because of the longer protection period for the patent whose examination should be requested in the second stage, expressed as the first term in the bracket: $(\underline{\mu_i} + m\frac{1+\lambda_i}{2} - \gamma) > 0$.[13] Therefore, we find that the reduction of the allowable period increases the rate of the early examination request by reducing the invention quality threshold ($-\frac{\partial \underline{\mu_i}}{\partial L} < 0$), if (a) the amount of information of the signal is large, i.e., m_L is large or (b) the blocking value of a pending application is large; that is, b_i is large. In Figure 1, such effect is represented as the downward shift of the horizontal invention quality threshold line.

Proposition 3 (early examination request)

[13] It is important to note that this is clearly an artifact of the model, since in the continuous model, a firm can choose to request an examination at any time during the deferral period.

The shortening of the period of an examination request decreases the average quality of inventions subject to early examination ($\partial \underline{\mu}_i / \partial L > 0$), or, equivalently, it increases the rate of early examination requests, especially in the sectors where the importance of screening (m_L) is high, or the blocking value of a pending application (b_i) is large

The expected effects of policy changes are summarized in Table 1.

[Place Table 1 approximately here]

4. The Data

4.1 The examination request system and policy reform in Japan

The examination request system was introduced to Japan in 1971. An examination request is made for each patent application.[14] It can be made by anyone and is irrevocable. We estimate that the third parties account for around 0.5 % of the examination requests made during the sample period. As indicated above, the maximum pending period was reduced from seven to three years in 2001.[15]

[14] Before the introduction of the multiple claim system in 1988, most patent applications included only one claim. The number of claims per application has been increasing since 1988. We control for the number of claims in our estimation, since it could affect the examination of request behaviors.

[15] Following this policy change, the JPO fee structure was revised in 2004, so as to increase the examination

4.2 Data collection

We use two types of data: patent data and financial accounting data. Our patent data is obtained from IIP Patent Database (IIP-DB)[16] and Industrial Property Digital Library (IPDL). The accounting data is from the NEEDS Database, provided by Nihon Keizai Shimbun, Inc. We have employed the IPDL to extend the examination request data in IIP-DB until December 2008.[17] Therefore, in our dataset, all applications filed by December 2005 have exhausted their allowable examination request periods; thus, there are no truncation problems. We restrict our analysis to the firms that were publicly traded from 1986-2005 and that disclosed their R&D expenses during this whole period (704 firms). We matched patent data to these firms, using their harmonized names and addresses. As a result, the final number of sample firms is 697. Our sample covers, on average, about 50.6% of all patent applications in Japan from 1986 to 2005.

Our estimations are based on individual patent application data. We define our focal explanatory variables on uncertainty at the International Patent Classification (IPC)

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request fee to the level of the marginal cost, while reducing annual fees (and application fees) in order to maintain revenue-neutrality. This increased the total expected cost of patenting for "low-quality" inventions and decreased such cost for "high-quality" inventions, where we measure the quality of patent applications by the probability of them being granted and the average length of their maintenance periods, once granted.

[16] IIP-DB is provided by Institute of Intellectual Property and A Life-Laboratory. It covers the patents filed with the Japan Patent Office, and consists of patent application files, registration files, applicant files, right holder files, citation information files, and inventor files. The detailed explanation of IIP-DB is given by Goto and Motohashi (2007).

[17] The last publication date of the application included in IIP-DB is the end of May 2008. IPDL offers the public access to IP Gazettes of the JPO through the internet.

class (roughly 120 IPC classes) level. We will compare the magnitude of the effect of policy reform on the examination request decision for the patent applications in the IPC classes with higher uncertainty and for the other IPC classes. We use monthly (not yearly) data in order to identify the impact of the reforms of the examination request system, which took place in October 2001; we introduce IPC by year dummies as control variables in our estimations. The last application month of our patent data is December 2005.

For the dependent variables, we use two dummy variables: "eventual examination request" dummy and the "early examination request" dummy. The variable "eventual examination request" represents whether the firm eventually requests an examination for the application within the allowable period. The variable "early examination request" indicates whether the firm makes an examination request at the same time as the date of patent application.

4.3 Brief overview of overall trend

We start with some descriptive information about our dataset. Figure 2 shows the number of examination requests of our sample in 2005 by elapsed months from the date of application. The profile of examination requests had two peaks over the deferral period in Japan. The first peak was close to the date of application. The second, bigger peak occurred around the end of the allowable period of examination requests. This is consistent with the framework of the theoretical model discussed above.

[Place Figure 2 approximately here]

Figure 3 illustrates the rate of eventual examination requests, the total number of applications, and the average number of claims of those applications by application year.[18] We draw this figure from patent application-level yearly data, although our estimations are based on monthly data. The rate of eventual examination requests shows a gradual but substantial increase of around 15 % points from 1988 to 2001, with an increase in the number of claims per patent, while the rate shows a jump in 2002. Our later econometric analysis finds that these changes significantly reflect the gradual increase of the number of claims and the shortening of the period of examination request in 2001.

[Place Figure 3 approximately here]

Table 2 reveals the changes in the rate of eventual examination request by industries from September 2001 to October 2001 for the top five and the bottom five industries.[19]

[18] Note that the number of applications and examination requests are fractionally counted by the number of applicants in this paper, so as to avoid the double counting of the co-applied patents.
[19] In Table 2, we ignored the industry where the average number of applications is lower than 20.

The rate of eventual examination requests in the pharmaceutical industry was, on average, 50.3 % for the applications filed in September 2001, and it increased to 76.5 % for those filed in October 2001. Table 2 indicates that the impact of the reduction of the allowable period for examination request is larger in the industries where the degree of uncertainty about the value of patenting is high.

[Place Table 2 approximately here]

Table 3 indicates the grant rate (the ratio of the number of granted patents to the number of applications) in 1998 and in 2002. Given the introduction of the new policy in 2001, the final date of the allowable period of examination requests in both application years was 2005. We find that the grant rate significantly increased (up by 4.5 % points from 32.7 %) after the reduction of the available period of examination requests. This indicates that the reduction of the deferral period increased examination requests, which in turn led to more granted patents.

[Place Table 3 approximately here]

4.4 Estimation framework

We estimate the following equation to analyze the effects of the policy reform on the eventual and early examination request decision.

$$Request_{i,t} = \beta_0 + \beta_1\, shorten_t + \beta_2\, (blocking_j \times shorten_t)$$

$$+\beta_3\, lnclaim_{i,t} + \beta_4\, lncited_{i,t} + \beta_5\, rdint_{k,Y} + \beta_6\, lnasset_{k,Y} + \beta_7\, lnipcap_{j,t}$$

$$+\sum_k \sum_j \gamma_{k,j}\left(firm_k \times IPC_j\right) + \sum_j \sum_t \omega_{j,t}\left(IPC_j \times year_Y\right) + \theta_j + \tau_Y + \varepsilon_{i,t}. \qquad (18)$$

In this specification, i denotes a patent application, k denotes the firm that filed the patent application, j the main IPC class of the patent applications, t the monthly time, and Y the yearly time. The vectors $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\omega}$ are the coefficient parameters. The variables θ_j and τ_Y are IPC dummies and year dummies. We introduce the cross term of firm dummies and IPC dummies, $\sum_k \sum_j \gamma_{k,j}\left(firm_k \times IPC_j\right)$ and the cross term of IPC dummies and year dummies, $\sum_j \sum_t \omega_{j,t}\left(IPC_j \times year_Y\right)$. We include these dummy variables so as to control for the potential biases due to firm-specific differences in the patenting propensity and sector-specific differences in the importance of patenting. With these control variables, we can partially control for the variations of quality of applications across firms and technological fields, in the dimensions not measured by the number of claims and forward citations. We can also control for the technology field- or macro-level annual changes in demand, appropriability, and patent systems. The variable $\varepsilon_{i,t}$ is an error term.

The dependent variable $Request_{i,t}$ is the binary variables that reflect the decisions on making “eventual examination request” and “early examination request” for the patent application i filed at time t. The independent variable $shorten_t$ is the monthly step function variable, which takes value 0 before September 2001 and value 1 after October 2001. According to Proposition 1, the reduction of the allowable period increases the probability that the application is eventually requested examination.

Our central focus is on the screening feature of the examination request system. Proposition 2 suggests that the impact of the shortening of the period is larger in the technology area with higher uncertainty. To test this proposition, we compare the coefficients of the variable $shorten_t$ between the estimation results for the technology sectors with high uncertainty and those for the other sectors. As the indices of uncertainty, we use two variables constructed from the RIETI Inventor Survey on Innovation 2007.[20] The first index is related to the non-use rate and the other is regarding the share of the basic research. As for the first index, the survey asks the inventors of patent applications whether the patent is used and, if not, whether the blocking motivation is the main reason for non-use. We use a deviation of the average non-use rate in each technology

[20] The survey was conducted in 2007 by Research Institute of Economy, Trade and Industry. See Nagaoka and Walsh (2009) for a detailed explanation of this survey.

field (59 IPC sub-classes) from the overall mean, while non-use rate is defined as the ratio of the number of unused patents excluding those that are unused solely for the blocking motivation to the total number of patents for each technology field. Thus, our non-use rate does not reflect the blocking motivation and only measures the degree of uncertainty. Moreover, the survey collect an information on the stage of R&D which generated the invention under the survey; basic research, applied research and development. We use the share of the basic research in each IPC as another index of uncertainty. We will analyze whether the magnitude of coefficients of the variable $shorten_t$ differs between the subsamples with top 10% uncertainty and with bottom 90% uncertainty.

According to the Proposition 3, we expect that in a sector with a strong pending application blocking effect, the reduction of the maximum length is more likely to increase early examination requests. Since this effect can confound that of uncertainty, we need to control for it. We introduce a direct measure of the importance of a blocking motivation, which is also obtained from the RIETI Inventor Survey. It is the share of the "blocking" patents (those used by the applicant only for a blocking purpose) in all surveyed patents in each technology field. We denote a deviation of this share from the overall mean by $blocking_j$. Although there are two distinct types of blocking: ex-ante blocking of a pending application (expressed by B_i in the theoretical model) and the ex-post blocking of granted patents (which can increase μ_i and λ_i in our model), we cannot separately identify these two types of blocking values. Thus, it is important to note that the coefficient of the variable $blocking_j$ represents the effect of these two types of blocking motivations. The average non-use rate across technology fields, exclusive of blocking motivation, is 29.2 %, and the average rate of pure "blocking" patents is 13.6%.

Others are control variables. A variable $lnclaim_{i,t}$ is the logarithm of the number of claims for each patent application.[21] A variable $lncited_{i,t}$ is the logarithm of the number of forward citations that the application is received.[22] These variables measure and control for the quality of invention. A variable $rdint_{k,Y}$ is the R&D intensity of a firm, which is the relative scale of R&D expenditure to firm size, measured by the tangible asset. We use the logarithm of tangible asset ($lnasset_{k,Y}$) as the proxy variable of the firm's complementary assets. Since we use firm fixed effects, these variables control for the effects of inter-temporal changes of a firm's specific R&D capability and the size of its complementary assets. We include the logarithm of total number of applications in the relevant IPC class ($lnipcap_{j,t}$) to control for the variation of technological opportunity and

[21] We add the value 1 before taking the logarithm of the independent variables: ln(1+x).
[22] There is a truncation problem in that newer patent applications receive smaller number of citations. We control for this problem by introducing the technology fields by year dummies in the estimation.

patenting propensity over time.

The explanations and the descriptive statistics of all variables used in the estimations are summarized in Table A-1 and Table A-2 in Appendix.

4.4 Basic Estimation results

Table 4 reports the results of the OLS estimation of equation (18) for eventual and early examination requests. Our estimation limits the sample period to 5 years before and after policy change: 1997-2005.[23] In Table 4 the estimation models (1) and (2) use the full sample, while the models (3) and (4) use the subsamples that include only technology fields with "Top 10%" uncertainty measured by the share of basic research or the non-use rate, respectively. For the estimation on the eventual examination request, we added the estimation results with the samples of "Bottom 90%", by excluding the top 10% subsamples from the full sample, as in model (5) and (6).

[Place Table 4 approximately here]

One of our central interests is the effect of the shortening of the period of examination requests. The coefficients of *shorten* are highly significant and positive for both eventual

[23] We evaluate the effect of policy reform by using the symmetric pre- and post- length, while we overviewed the overall trend with longitudinal data that covers 20 years since 1986. Due to the limitation of processing capacity of the computer, we employ OLS estimation since the maximum likelihood estimation takes considerable time.

examination request and early examination request; model (1), (2), (7) and (8) in Table 4. We find that the reduction of the allowable period for patent examination requests increased the probability of making eventual examination request by about 8.7% points from 62.3 %. Furthermore, the rate of early examination request also significantly increased by 1.6 % points from 4.2 % because of the policy reform. These results are consistent with Proposition 1 (a) and Proposition 3.

The magnitude of the coefficients of the variable *shorten* for the eventual examination request is higher for the subsample of higher uncertainty. In the estimation model (3) and (4) for the eventual examination request, the coefficients are 0.113 and 0.113, compared with 0.0884 and 0.0893 in model (5) and (6). These differences are highly statistically significant.[24] This result supports Proposition 2. Specifically, the impact of the shortening of the allowable period becomes larger as the uncertainty becomes higher. Controlling for the blocking motivations of pending applications and granted patents does not materially affect the effect of uncertainty, since the coefficients of *shorten* have almost the same values for the model (1) and (2). The above evidence strongly suggest that the screening feature of the examination request system was quite important for the applicant and that the reduction of the allowable period significantly decreased the option

[24] The estimated standard deviations of the differences are 0.000016 and 0.000033.

value of postponing examination requests for this purpose. A blocking motivation has a significant and positive coefficient only for early examination request in model (7). These results are consistent with Proposition 1 (b) and Proposition (3).

Both the number of forward citations and the number of claims have highly significant coefficients in accounting for the level of the eventual examination requests. Higher invention quality is associated with lower threshold for examination requests (see equation (11) and Figure 1) , consistent with our theoretical model.

4.5 Robustness checks

As shown in Appendix (Table A-3), our main results explained above are robust even if we limit the sample period to just before and after policy reform, from October 2000 to November 2002, by which the results are less likely to be affected by the long-term trends. The coefficients of *shorten* have highly significant coefficients for both eventual and early examination requests, the sizes of which are similar to those reported in Table 4. The differences in the magnitude of coefficients between the fields with high uncertainty and those with the other are similar to the results with Table 4.

Furthermore, the results for early examination requests are also robust, even if we use the dummy variable reflecting the decision of examination request within 12 months from the date of applications as the dependent variable for early examination request (see Table A-4).

5. Conclusions

In this paper, we tested the major implications of real option theory on patent examination request behaviors, exploiting the responses of Japanese firms to the change of the deferred examination system.

Our theoretical analysis suggests that: (I) The reduction of the period allowable for examination requests leads to an increase in eventual examination requests, especially in the technology areas with high uncertainty, since it weakens the ex-ante screening of patent applications. (II) It also increases the firm's early examination requests, when the reduction of the allowable period for examination requests significantly reduces the learning opportunity on the value of patenting its application. The blocking value of a pending application also increases the impact of such policy on early examination requests, while it does not affect the level of eventual examination requests.

Our empirical analysis supports these implications. In particular, the reduction of the allowable period increased the probability of making eventual examination request by about 8.7 % points from 62.3 % even after controlling for the blocking effects of pending patent applications. Such an effect is stronger in technology areas with higher uncertainty. The reduction of the allowable period also increased the probability of making early examination request by about 1.6 % points from 4.2 %. These findings point to the importance of the ex-ante screening effect of the examination request system.

Our research has an important policy implication. A deferred patent examination system can potentially improve the welfare of all parties involved: a smaller number of granted patents (for third parties), fewer resources used for patent examination (for patent offices and applicants), and more ex-ante profit from R&D (for applicants). One potential negative consequence is a blocking effect of pending applications that do not meet patentability. This outcome could be controlled by allowing a third party to request patent examination, perhaps with a subsidized fee.

A number of additional issues remain to be analyzed. One potentially important effect of the shortening of the allowable period in Japan is that it constrains the opportunity of the patent office to collect information. This outcome may reduce the accuracy of the patent examinations. In a future research, we plan to examine how the accuracy of patent examinations has been affected by the acceleration of the examination process in Japan[25]. The second issue is the joint design of the deferred examination and renewal systems for realizing an efficient patent system. Such design needs to consider both uncertainty (inventor learning) and information asymmetry (examiner learning). A deferred examination may be less important if a patent renewal system can effectively solve both the uncertainty and information asymmetry problems. However, having multiple instruments may be advantageous. The third issue is an empirical assessment of the blocking effect of a pending application that is unlikely to meet patentability criteria. We intend to address this question by examining the results of examinations that were requested by third parties.

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Appendix A

[Place Tables A-1, A-2, A-3 and A-4 approximately here]

Fig. 1 Relation between thresholds of market size and invention quality

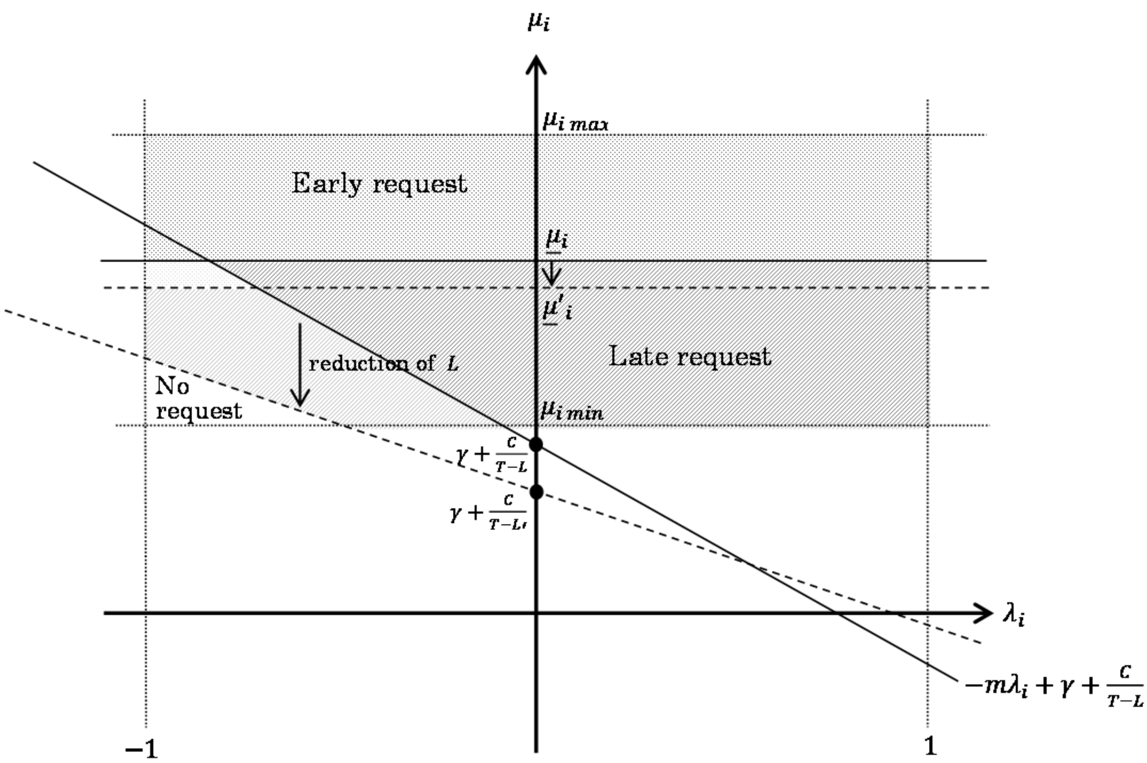

Fig. 2 Number of examination requests by elapsed months (in 2005)

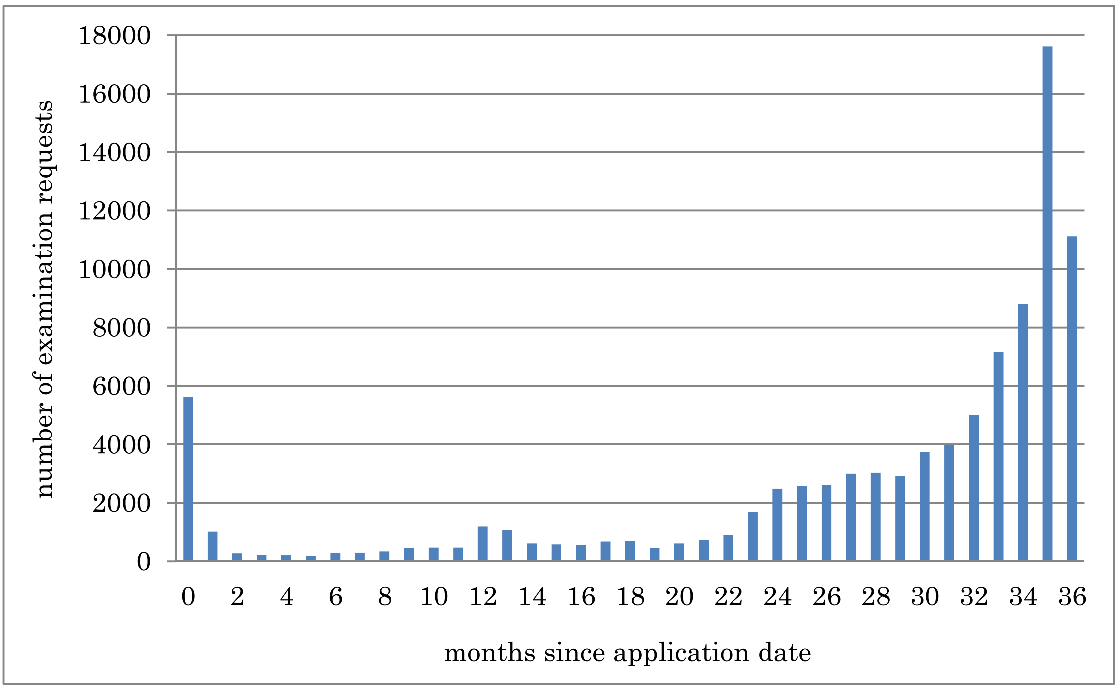

Table 1 Signs of the policy effects under Assumption 1

	Eventual examination request	Early examination request
Reduction of the allowable period (decrease in L)	+	+[(1)]
Reduction of the allowable period interacted with uncertainty (decrease in L when η is large)	+	

Note (1): When the importance of screening (m_L) is high and the blocking value of a pending application (b_i) is large

Fig. 3 Rate of eventual examination requests by application year

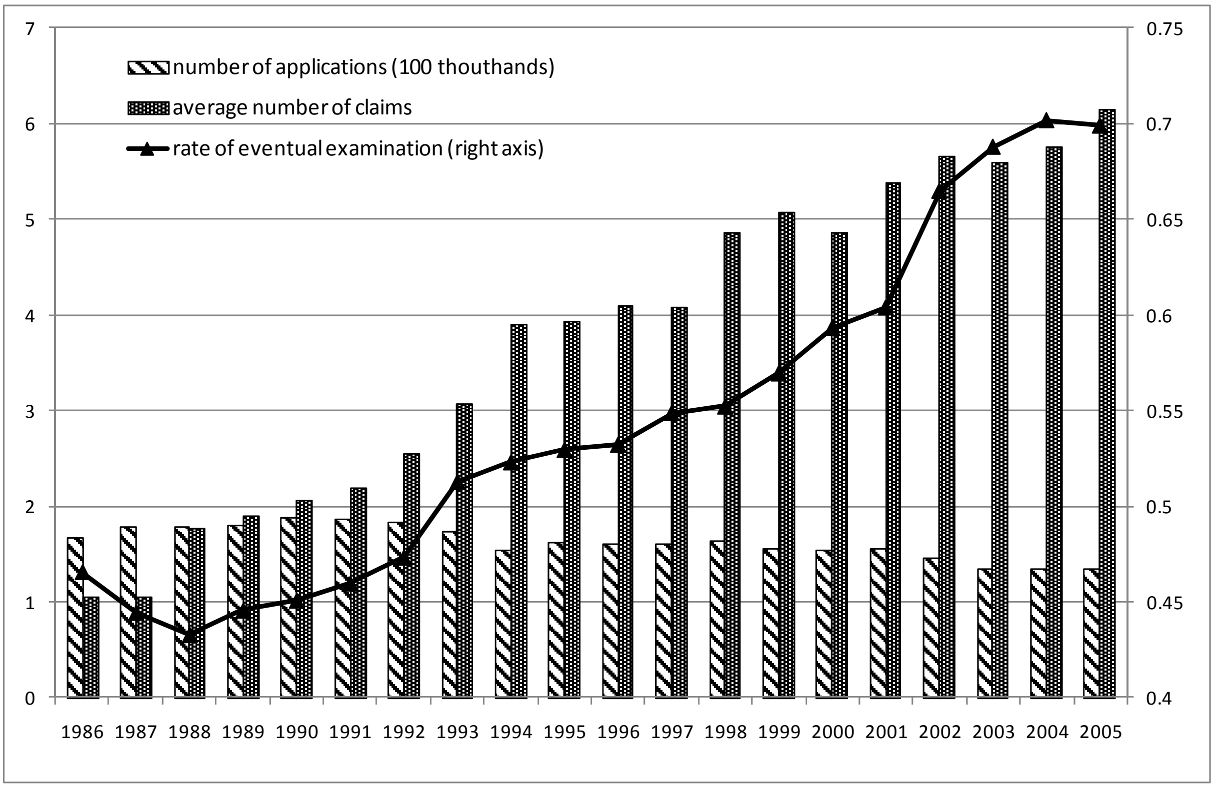

Table 2 Changes in the rate of examination requests after the reduction of the allowable period

Large increase (Top 5)				Decrease or small increase (Bottom 5)			
Industry	before (Sep. 2001)	after (Oct. 2001)	increase	Industry	before (Sep. 2001)	after (Oct. 2001)	increase
Pharmaceutical	50.3%	76.5%	26.2%	Communications	78.3%	66.3%	-12.0%
Ceramic	38.9%	64.2%	25.4%	Ship-building	62.9%	61.3%	-1.6%
Automobile	54.7%	79.5%	24.8%	Service	95.2%	96.6%	1.5%
Food	65.1%	81.6%	16.4%	Steel	65.5%	67.3%	1.8%
Chemical	47.9%	63.7%	15.8%	Gas	71.2%	73.0%	1.8%

Table 3 Changes in the grant rate after the reduction of the allowable period

year	Patent applications	Examination request rate	Grant rate (to applications)
1998	382,979	59.7%	32.7%
2002	392,486	71.9%	37.2%

Table 4 Impacts of reform on the examination request decisions: 1997-2005 (OLS)

	eventual examination request dummy						early examination request dummy	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	full sample		Top 10% basic research	Top 10% non-use rate	Bottom 90% basic research	Bottom 90% non-use rate	full sample	
$shorten_t$	0.0869***	0.0859***	0.113***	0.113***	0.0884***	0.0893***	0.0160***	0.0159***
	(30.49)	(33.24)	(12.42)	(7.276)	(27.47)	(28.75)	(13.52)	(14.95)
$blocking_j \times shorten_t$	-0.0338		-0.0472	-0.308	-0.107	-0.104	0.0617**	
	(-0.584)		(-0.181)	(-0.688)	(-1.550)	(-1.543)	(2.574)	
$lncited_{it}$	0.127***	0.126***	0.141***	0.147***	0.128***	0.128***	0.00223***	0.00240***
	(96.63)	(100.5)	(66.30)	(53.38)	(88.76)	(90.60)	(4.092)	(4.678)
$lnclaim_{it}$	0.0822***	0.0812***	0.0504***	0.0648***	0.0860***	0.0841***	-0.0211***	-0.0202***
	(113.9)	(117.9)	(31.18)	(31.45)	(108.9)	(109.0)	(-70.42)	(-71.36)
$rdint_{kY}$	0.00712*	0.00470	-0.0451***	-0.102***	0.0115***	0.00866**	0.0634***	0.0611***
	(1.862)	(1.262)	(-3.980)	(-7.089)	(2.808)	(2.169)	(40.00)	(39.99)
$lnasset_{kY}$	-0.0306***	-0.0318***	-0.0697***	-0.0722***	-0.0287***	-0.0300***	0.0104***	0.00994***
	(-18.14)	(-19.48)	(-17.30)	(-20.18)	(-16.11)	(-16.61)	(14.92)	(14.84)
$lnipcap_{jt}$	0.109	-0.0172	-0.0276	-0.0120	0.0312	0.00676	-0.0149	0.0934
	(0.000332)	(-4.12e-05)	(-0.646)	(-0.481)	(0.000174)	(2.18e-05)	(-0.000110)	(0.000545)
Constant	-0.113	0.942	1.516***	1.379***	0.483	0.694	0.0563	-0.805
	(-4.10e-05)	(0.000285)	(4.632)	(6.569)	(0.000307)	(0.000269)	(4.94e-05)	(-0.000596)
IPC	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes
*IPC*year*	yes	yes	yes	yes	yes	yes	yes	yes
*firm*IPC*	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,276,373	1,435,351	315,845	180,847	1,045,163	1,103,771	1,276,373	1,435,351
R-squared	0.036	0.036	0.034	0.045	0.038	0.037	0.018	0.017

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A-1 Explanations of variables

Variable	Explanation	Level
$shorten_t$	Dummy variable that takes 1 after shortening of the period of examination request (in October 2001)	monthly
$uncertainty_j$	Deviation of the average nonuse rate (excluding the blocking motivation) in each technologicaly field (59 IPC sub-classes) from the overall mean / Share of the basic research in each technologicaly field	IPC
$blocking_j$	Deviation of the fraction of the unused patents by reason of blocking among the all unused patents in each technology field to the overall mean	IPC
$blocking_j \times shorten_t$	Cross term of *blocing* and *shorten*	IPC, monthly
$lncited_{it}$	Logarithm of the number of forward citations	patent, monthly
$lnclaim_{it}$	Logarithm of the number of claims	patent, monthly
$rdint_{kY}$	R&D intensity (=R&D/tangible asset)	firm, yearly
$lnasset_{kY}$	Logarithm of tangible asset	firm, yearly
$lnipcap_{jt}$	Logarithm of total number of applications in relevant IPC	IPC, monthly

Table A-2 Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
eventual examination request	1437738	0.623	0.485	0.000	1.000
early examination request	1437738	0.042	0.200	0.000	1.000
shorten	1437738	0.432	0.495	0.000	1.000
uncertainty (nonuse rate)	1278602	0.054	0.078	-0.292	0.258
uncertainty (basic research)	1278602	0.178	0.095	0.000	0.561
blocking	1278602	0.014	0.048	-0.136	0.214
blocking×shorten	1278602	0.007	0.032	-0.136	0.214
lncited	1437738	0.124	0.320	0.000	4.263
lnclaim	1435351	1.894	0.631	0.693	5.951
rdint	1437738	0.254	0.245	0.000	21.457
lnasset	1437738	11.917	1.314	3.497	16.296
lnipcap	1437738	8.080	1.317	0.087	9.769

Table A-3 Estimation results restricting the sample period: Oct. 2000 – Nov. 2002 (OLS)

	eventual examination request dummy						early examination request dummy	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	full sample		Top 10% basic research	Top 10% non-use rate	Bottom 90% basic research	Bottom 90% non-use rate	full sample	
$shorten_t$	0.0856***	0.0844***	0.106***	0.116***	0.0869***	0.0877***	0.0152***	0.0149***
	(29.66)	(32.30)	(11.81)	(7.372)	(26.72)	(27.92)	(12.86)	(14.00)
$blocking_j \times shorten_t$	-0.0222		0.0570	-0.283	-0.0920	-0.0876	0.0630***	
	(-0.377)		(0.220)	(-0.624)	(-1.315)	(-1.283)	(2.612)	
$lncited_{it}$	0.119***	0.117***	0.126***	0.140***	0.120***	0.119***	0.00842***	0.00922***
	(39.04)	(40.19)	(13.07)	(11.04)	(35.72)	(36.48)	(6.723)	(7.758)
$lnclaim_{it}$	0.0907***	0.0897***	0.0673***	0.0918***	0.0955***	0.0927***	-0.0138***	-0.0130***
	(62.47)	(64.58)	(14.61)	(15.88)	(60.29)	(59.76)	(-23.17)	(-23.01)
$rdint_{kY}$	0.259***	0.249***	-0.199*	0.0946	0.379***	0.310***	0.107***	0.100***
	(5.774)	(5.667)	(-1.745)	(0.659)	(7.490)	(6.345)	(5.820)	(5.594)
$lnasset_{kY}$	0.0379***	0.0319***	-0.0528	0.0837	0.0594***	0.0437***	-0.0193***	-0.0174***
	(3.002)	(2.658)	(-1.259)	(1.456)	(4.207)	(3.180)	(-3.729)	(-3.570)
$lnipcap_{jt}$	-	-0.0710	-	-	-	-	-	0.00305
		(-0.000106)						(1.11e-05)
Constant	-0.102	0.557	1.127**	-0.649	-0.404	-0.194	0.257***	0.212
	(-0.658)	(0.000103)	(2.316)	(-0.934)	(-0.000271)	(-1.142)	(4.034)	(9.65e-05)
IPC	yes	yes	yes	yes	yes	yes	yes	yes
year	yes	yes	yes	yes	yes	yes	yes	yes
*IPC*year*	yes	yes	yes	yes	yes	yes	yes	yes
*firm*IPC*	yes	yes	yes	yes	yes	yes	yes	yes
Observations	317,175	355,925	35,507	20,803	258,479	273,183	317,175	355,925
R-squared	0.028	0.028	0.023	0.030	0.031	0.029	0.005	0.005

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A-4 Impacts of reforms on early examination requests
(using examination requests within 12 months from application dates)

	examination request within 12 months			
	full sample		limited sample period (Oct. 2000 - Nov. 2001)	
	(1)	(2)	(3)	(4)
shorten $_t$	0.0231***	0.0231***	0.0215***	0.0216***
	(15.38)	(17.00)	(13.73)	(15.25)
blocking $_j$ ×*shorten* $_t$	0.0859***		0.0928***	
	(2.818)		(2.902)	
lncited $_{it}$	0.00797***	0.00826***	0.0166***	0.0178***
	(11.49)	(12.56)	(9.986)	(11.24)
lnclaim $_{it}$	-0.0182***	-0.0175***	-0.00946***	-0.00840***
	(-47.90)	(-48.40)	(-12.00)	(-11.16)
rdint $_{kY}$	0.0887***	0.0861***	0.303***	0.288***
	(44.03)	(43.97)	(12.44)	(12.12)
lnasset $_{kY}$	0.0385***	0.0364***	0.180***	0.170***
	(43.33)	(42.43)	(26.20)	(26.14)
lnipcap $_{jt}$	0.00978	0.0983	-	-0.157
	(5.66e-05)	(0.000448)		(-0.000430)
Constant	-0.469	-1.133	-2.140***	-0.753
	(-0.000324)	(-0.000654)	(-25.33)	(-0.000258)
IPC	yes	yes	yes	yes
year	yes	yes	yes	yes
*IPC*year*	yes	yes	yes	yes
*firm*IPC*	yes	yes	yes	yes
Observations	1,276,373	1,435,351	317,175	355,925
R-squared	0.009	0.009	0.006	0.006

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1