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Does the outsourcing of prior art search increase the efficiency of patent examination?†

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Abstract

This paper investigates the effects of outsourcing of prior art search on the efficiency of patent examination, using a large scale Japanese patent examination data. Outsourcing may increase examination quality by expanding the scope of prior art search, while it may have a negative effect if the synergy between search and examination is important. If examination quality is the predominant concern for outsourcing decision and the outsourcing is constrained by budgetary resources, we expect that outsourcing enhances examination quality at its margin. On the other hand, if an examiner can save private cost by outsourcing, an increase in outsourcing can decrease the quality. Controlling for the endogeneity of outsourcing decision as well as examiners' fixed effects, we found that the outsourcing of prior art search significantly decreased the frequency of appeals against both examiners' rejection and grant decisions and reduced the length of examination duration. At the same time we found that the prior art search of complex inventions is not outsourced. These suggest that the opportunity for exploiting external knowledge and capability can increase the quality as well as the speed of examination.

JEL classification numbers: O38, O34, O30

Keyword: patent, examination, outsourcing, search, prior art

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1. Introduction

Patent system should be designed to effectively promote innovation. Especially, the outcome of patent examination defines the scope of public domain and affects the appropriability of firms' R&D. The timely completion of an examination is also important for that objective. Therefore, the design of efficient patent examination process is crucial to keep the patent system functional. The global surge of patent applications causes a great concern about the increasing backlog of pending patent applications in many countries. The increased backlog delays the examination process due to the overload problem of examiners, which can decrease the quality of examination and lead to an increase in the patents with dubious patentability. The increasing complexity of inventions also aggravates the problem.

In response to this concern, the Japan Patent Office (JPO) has increased outsourcing of prior art search, in order to reduce the pendency period and to maintain adequate quality of patent examination. The JPO spent about 236 million dollars (calculated at 1 USD = 90 yen) for outsourcing in 2010, while the total labour cost of the JPO is 371 million dollars. The number of applications of which the prior art search is outsourced reached 246 thousands in 2010 (about 65% of all examined applications). The cost of outsourcing per examined applications is about 947 USD, which can account for 40 % of the direct cost of patent examination[1].

Due to the large investment in outsourcing, the number of decisions per examiner per month has been significantly increasing: the average number of monthly examinations per examiner increased from 13.6 to 16.0 between 1999 and 2007, as the rate of outsourcing increased from 30% to 70%[2].

The decision on which applications should be outsourced is left to individual examiners, though there is a limitation on the maximum number of outsourcing per month due to the budget constraint. Note that the individual examiners take ultimate responsibility for the search results even when they outsourced the prior art search. Therefore, they supplement the search results if needed in the examination.

The work of patent examiners is divided into two tasks: (1) searching prior art in patents and published literature for identifying relevant prior art for the evaluation of novelty and inventive step, and (2) substantive examination of whether the invention meets the patentability requirements (novelty, non-obviousness and industrial application). The central question of this paper is whether the outsourcing of prior art search increases the efficiency of patent examination process measured in terms of quality and speed, given that the volume of

[1] According to the JPO's estimates, the direct cost of examination is 22,000 yen (244 USD) per claim in 2010. Therefore, the direct cost of examination per examined application is assumed to be about 209,000 yen (2,322 USD) as the average number of claims per application is 9.5 in 2010.

[2] In the previous version of this paper, using the examiner-level panel data, we found that the number of decisions of each examiner per month increased by about 39 % on average as the rate of outsourcing of prior art search increased from 0% to 100%.

examination per examiner significantly increased due to outsourcing.

One possible view ("*synergy view*") is that the quality and the speed of examination become higher if the same examiner conducts both prior art search and substantive examination. This is because the integration of two closely interconnected tasks deepens the examiner's understanding of the contents of the invention and enhances the efficiency of both search and examination. The integration can also save the time necessary for communication and coordination between two individuals, examiners and searchers, if the two tasks are divided. An alternative view ("*search scope view*") is that the outsourcing of prior art search enhances the efficiency of the examination process, since the examiner can take advantage of the search ability of the searchers specialized in prior art identification and thus he can expand the potential search scope. Identifying the adequate prior art is a vital step in the patent examination.

The European Patent Office (EPO) pursues the *synergy view*, where a single lead examiner undertakes both search and examination under the "BEST" ("Bringing Examination and Search Together") program. On the other hand the JPO takes the *search scope view*, substantially because the JPO has not been able to significantly increase the number of examiners, given the budgetary ceiling on the number of civil servants in Japan.

This paper tries to identify which view is true under the specific circumstances, using the Japanese patent examination data. In reality we expect that both forces are at work. Especially, if examination quality is the predominant concern in an outsourcing decision and the outsourcing is constrained by budgetary resources, we expect that outsourcing enhances examination quality at its margin. We found that the outsourcing of prior art search significantly decreased the frequency of appeals against the rejection decisions as well as against the grant decisions of examiners, controlling for the endogeneity of outsourcing, the complexity of examination task, the value of patenting the inventions and the differences in the examiners (that is, examiners' fixed effects). We also found that the outsourcing increased the speed of examination by reducing the period of communications between examiners and applicants in both grant and rejection process. These effects are still observed despite of the fact that the volume of final decisions by an examiner per unit of time increases significantly with an increase in outsourcing of prior art search.

These results suggest that the outsourcing of prior art search has increased the quality as well as the speed of examination. It is noteworthy that, according to our estimation results, outsourcing is chosen for less complex patent applications, which indicates the advantage of integrating two tasks for complex patent applications. Therefore, giving an examiner an option to use the outsourcing of prior art search can play an important role for improving the efficiency of patent examination, given the large variety of the complexity of inventions.

The rest of the paper is organized as follows. Section 2 surveys related studies, and Section 3 describes the data. We provide the analytical and estimation framework in Section 4, and estimation results in Section 5. Finally, Section 6 concludes the paper.

2. Related Studies

Not many but some studies address the issue of patent examination process. However, empirical analysis focusing on the quality of examination process is scarce and, to the best of our knowledge, no studies have analyzed the effects of outsourcing.

The most related paper is Harhoff and Wagner (2009). They analyze the determinants of the examination duration, and identify the different effects on the granted, withdrawn and refused applications. They divide the main determinants into three groups: the characteristics of applicants, the value related characteristics of inventions, and the complexity of examination task. According to their study, the potentially valuable applications are granted earlier and withdrawn slower. Moreover, they show that more complex inventions, measured by the number of claims and backward citations, need more time to complete the examination process. However, they do not analyze the effects on the quality of examination in terms of the frequency of the appeals against the decisions of the Patent Offices.

Caillaud and Duchene (2011) theoretically analyze how the workload of examiners affects the firms' R&D incentives, assuming the tradeoff between the workload and the quality of examination. They suggest that the introduction of a penalty system on the applicants for rejected patent applications and the commitment of the non-obviousness standard could attain the high-R&D equilibrium, since those policies increase the firms' incentive to screen out the low-quality inventions, and thus reduce the workload of examiners and increase the quality of examination.

Based on the queuing theory, Sharon and Liu (2008) simulate the impacts of institutional factors on the pending applications in the U.S. According to their simulation results, the restriction on the number of the times of non-final rejection significantly decreases the backlogs, while the restrictions on the number of times of requests for continued examination or continuations have little effect.

Batabyal and Nijkamp (2008) is another theoretical study which applies the queuing theory. Assuming the tradeoff between the quality and the speed of examination, they compare the desirability of two policy regimes: the speed-oriented examination with a small number of examiners, and the accuracy-oriented examination with a large number of examiners. They suggest that the former regime is rational when the pendency period is a great concern and the latter is desirable when the quality of examination is regarded as a big problem.

Cockburn et al. (2002), focusing on the characteristics of examiners, empirically shows that the examination process significantly varies across examiners. They find that the number and the pattern of citations and the grant rate differ depending on the examiner's experience, specialty, workloads and examination period per application. On the other hand, they also find that the experience and workloads of examiners have little effect on the frequency of invalidation, which implies the quality of examination does not depend on the variation of examiners.

Regibeau and Rockett (2010) show that the more important inventions are examined earlier when they control for the life cycle of technology, and the more advanced technologies are examined slower when they control for the quality of inventions. Their analysis is based on the assumptions that an applicant has an incentive to accelerate the examination process for its important inventions over the life cycle of technology, while an examiner can evaluate the application more accurately by delaying the decision and accumulating more technological knowledge. Thus, their analysis recognizes knowledge constraint in the patent examination, which could be alleviated using external knowledge.

There are some empirical studies which focus on the applicants' strategic motivation. Lemley and Sampat (2010) suggest that an applicant uses the continuation to delay the examination process so that she can keep the opportunity to amend the contents of applications according to the market situation.

Sampat (2010) analyses the applicant's effort for the prior art search, and find that the share of applicant's citations against the examiner's citations becomes higher when the invention is more important for the applicant. This result indicates that the applicant's incentive to contribute to the prior art search significantly differs due to the applicant's strategic motivation.

These studies show that the duration of patent examination varies depending on the applicant's motivation. Relating to this point, Palangkaraya et. al. (2008) and Henkel and Jell (2010), focusing on the firm's examination request behavior, suggest that the applicants have an incentive to prolong the examination process due to the strategic motivation such as increasing the third party's uncertainty. However, according to Yamauchi and Nagaoka (2009), another and more important motivation of applicants to delay their decision on examination request could be to learn the value of their applications.

Pop et al. (2003) focuses on the characteristics of invention and suggests that the main determinant factor of the increasing examination duration is the complexity of technology rather than the applicant characteristics.

In this paper, different form the above existing studies, we investigate the effects of policy tool such as an outsourcing of prior art search on the efficiency of examination process from the viewpoint of the speed and quality, using the patent level data. In assessing the quality of the examination, we use the frequency of appeals against the grant and the rejection decisions by the Patent office. Based on the Harhoff and Wagner's research, we introduce the complexity of the examination task and the value of patenting an invention for an applicant, as the determinants of examination outcome and the efficiency of the examination. We also control for the differences among examiners, which would otherwise affect the efficiency of examination suggested by Cockburn et al. (2002). After controlling for these factors, we identify the circumstances where the *scope of search view* adopted in Japanese examination process is more efficient to improve the examination performance.

3. Data and descriptive statistics

3.1 Data source

The patent data we use here is obtained from PatR Database provided by ALIFE-Laboratory, which is constructed from the processing data of JPO (Seiri Hyojunka Data)[3] for the purpose of statistical analysis. It covers all patent applications filed with the JPO and includes the examination outcomes. We matched the information on the outsourcing of prior art search and examiner code provided by the JPO to the patent application data of PatR. We restrict our sample to the applications that were applied and requested for examinations between 1996 and 2007, so that we can get almost complete information on the outsourcing and examination results[4].

Japan has an examination request system, under which an examiner undertakes the examination only after receiving a request for examination from the applicant. The allowable period of examination request was seven years for the applications filed before September 2001, and it was reduced to three years for the applications filed after October 2001. Restricting our sample to the applications requested examination by December 2007, we can use information on most of the final decisions with the latest PatR, though the decisions have not been made for a small percentage of patent applications.

3.2 Examination process

Figure 1 illustrates a brief overview of Japanese examination process. In this paper, we define the examination duration as the period between the date of applicant's examination request and the date of examiner's final decision, since the information on the starting date of examination is not available.

[Figure 1]

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[3] The database consists of patent application file, registration file, applicant file, right holder file, citation information file and inventor file (see Goto and Motohashi (2007) for detailed explanation).

[4] There are many missing values in outsourcing data for the applications requested examination before 1996. This made us decide to use the data after 1996.

Within 60 days from the posting date of the notice of reasons for refusal, an applicant can submit a written argument to explain the difference of the invention from the prior art and can amend the claims to remove the reasons for refusal. Then, the examiner reconsiders the patentability of the invention. There are no limitations about the number of submissions of the arguments and the amendments.

An applicant can withdraw its application anytime it wants. A withdrawal occurs mainly when the applicant thinks of its application as non-patentable after reading the examiner's negative opinion.

We define the period between the date of the first action (the first notification from the examiner) and the date of the final decision as the communication period. Note that the prior art search is basically conducted before the first action. Therefore, communication period is a useful index to measure not only the speed of examination but also the adequacy of the search, since high quality search should reduce the applicants' need to communicate with examiners.

When the applicant is dissatisfied with the final decision, she can appeal for reversing the decision of refusal. Similarly, the third party can appeal for invalidating the granted patent when they doubt the patentability of the inventions. Note that an applicant has to submit an appeal to the refusal decision within 90 days from the examiner's decision, while the invalidation trial can be appealed at any time by anyone. We assume that the frequency of the appeals measures the quality of examinations.

3.3 Brief overview of overall trend

Responding to the sharp increase in examination requests, the JPO has increased the number of outsourcing of prior art search. We draw, in Figure 2, the outsourcing rate as a line graph by examination request year. It is defined as the ratio of the examined applications for which examiners outsourced the prior art search to the overall examined applications. The bar graphs are the number of examination requests and the number of outsourcing. Note that the number of examination requests has almost the same meaning as the total number of examined applications, since most of the applications requested examinations by 2007 had their final decisions.

The outsourcing rate shows a sharp increase from late 1990s to early 2000s. However it has been stable at about 70% after 2002, which would be partly because of the supply constraint of the contractors for outsourcing. The allowable period for examination requests was reduced from seven years to three years for the applications filed after 2001. Therefore, there are overlaps of examination requests for the applications made before and after the policy change, which leads to the significant increase in the examination requests during the years following the policy change, especially between 2004 and 2007, in examination request year in Figure 2.

[Figure 2]

Figure 3 and Figure 4 depicts the rate of appeals against the refusal decisions and the rate of appeals for the patent invalidations by examination request year, respectively. These rates are the quality indices of examination process, which are the ratio of the appeals to the number of refusal decisions and to the number of grant decisions. We also draw the rates separately for the outsourced applications and for the non-outsourced applications. These figures show that the frequency of appeals is significantly higher for the non-outsourced applications than for the outsourced applications[5].

[Figure 3]

[Figure 4]

Figure 5 shows the length of the communication period defined as the monthly length between the date of the first action and the date of the final decision as line graphs by examination request year. We divide the sample into outsourced applications and non-outsourced applications. We also depict the total examination duration as bar graph. We find that the communication period has been gradually decreasing, while the total examination duration shows an increasing trend after 1998. This indicates the first action period has been increasing, due to the increased backlog of pending applications. According to this figure, the average communication period is about 7 months for the applications requested examinations in 2007. This figure also shows that the communication period of outsourced applications is shorter than that of non-outsourced applications. This result suggests that the outsourcing contributes to reducing the number of communications between examiners and applicants.

[Figure 5]

Figure 6 shows the changes in the characteristics of examined applications by examination request year; the number of claims, the number of IPCs[6], the number of inventors and the number of related prior arts the applicant referred to in published patent documents. The last variable is the number of cited patents by inventors in the description part of the patent document, which was specified by text mining in the published documents[7]. We call this

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[5] We can see, in Figure 3 and 4, the data on appeals is truncated, and we will control for this truncation problem by introducing year dummies in the estimation model.

[6] IPC stands for International Patent Classification. The technical content of patent documents is classified using the IPC system. We use IPC-class level (3 digits) data, which have roughly 120 categories.

[7] The detailed explanation of the data and method is given in Suzuki et al. (2008).

variable as the number of inventor citations.

These variables can capture the complexity of inventions and difficulty of the examination task. According to this figure, the numbers of claims, inventors and inventor citations per application have been increasing, whereas the number of IPCs included in one application shows a decreasing trend. This result suggests that the technological knowledge necessary for examination has been getting deeper and the scope of a patent has been getting narrower, which would increase the complexity of examination task.

[Figure 6]

Figure 7 shows the share of the applications simultaneously requested for an examination with the filing of applications ("rate of simultaneous examination request") and the share of the applications for which applicants use the accelerated examination system, by application year. In Japan, an applicant can significantly reduce the patent pendency period by submitting an accelerated examination request with no additional fees if the application meets the requirement to use the system. These indices can reflect the applicant's need for early patent protection, and we find it has been consistently increasing over the sample period. This would have been an additional source of increasing burden on examiners.

[Figure 7]

4 Analytical framework and estimation model

4.1 Analytical framework

We consider the following simple model of the choice of outsourcing of the prior art search. If the examiner does the search, he incurs the direct labor cost for a search and examination (denoted by l), and the expected psychological cost $p\theta$ from making a wrong decision, where p means the probability of making a wrong decision and θ is the psychological cost. If an examiner decides to outsource the prior art search, he can avoid doing the initial search, though he incurs the costs of verifying the search result and of a supplementary search when needed. We can write the sum of these verification costs and examination cost as v, which includes the communication cost between the external searcher and the examiner. We assume that the probability of making a wrong decision p depends on the complexity of the search and examination task z of a patent application, while l and v are independent of z for simplicity[8].

[8] The following analysis holds even if l and v increases with z, as long as the difference between the two is independent of z.

Given these assumptions, the expected private cost of an internal search of the prior art is given by the following equation (the upper script i stands for internalization of the search):

internal search: $c^i = l + p^i(z)\,\theta$. (1)

The expected cost of outsourcing the prior art search for a patent application with complexity z is given by the following equation (the upper script o stands for outsourcing of the search):

outsource: $c^o = v + p^o(z\,)\,\theta$, (2)

where the probability of making a decision error is given by p^o under the outsourcing.

We assume that an examiner has pending applications with mass of 1 indexed by z over $[0, 1]$. According to the *search scope view*, outsourcing could expand the search scope for prior literature since the examiner undertakes a supplementary search if necessary. This could increase the quality of patent examination and would result in the decrease of a wrong decision by an examiner. On the other hand, according to the *synergy view*, outsourcing results in less understanding of the invention by the examiner, which will reduce the quality of both tasks. These two views are not mutually exclusive and both forces work simultaneously. We assume that the tasks are ordered according to the relative importance of the *search scope view*. That is, the size of the reduction of the probability of making an error in examination due to outsourcing ($g(z) = p^i(z) - p^o(z)$) is a monotonic decreasing function of z. Moreover, we assume that outsourcing is not always better in the range of $z \in [0,1]$, that is, for some tasks integration is better: $g(z)$ is positive for any $z < \bar{z}$ where $\bar{z}$ satisfies $g(\bar{z})=0$ for $\bar{z} \in [0,1]$, and $g(z)$ is negative when $z \geq \bar{z}$.

We assume that an examiner will decide whether it will outsource prior art search or not, in order to minimize the total expected private cost, subject to the budgetary constraint on the total number of outsourcing.

First, we consider the benchmark case where the examiner acts to minimize the aggregate probability of making errors in examination. This would be the case if there is no difference between l and v or if the perceived penalty from a wrong decision is very large. If the maximum budget available for the outsourcing (denoted by b) is less than $\bar{z}$, then the prior art search for the tasks between $[0, b]$ are outsourced and the search for the rest of tasks are internally done, as illustrated in Figure 8. Therefore, the expected aggregate probability of making an examination error E^* is written as the following equation.

$$E^{*} = \int_0^b p^o(n)dn + \int_b^1 p^i(m)dm \quad (3)$$

If the budget becomes more generous for outsourcing under the situation that the budget constraint is binding, the expected probability of making an examination error decreases:

$$\partial E^{*}/\partial b = -\{p^i(b) - p^o(b)\} < 0 \quad \text{if} \quad b \leq \bar{z} \ . \quad (4)$$

[Figure 8]

If, however, the budget is not binding ($b > \bar{z}$), only the tasks up to $\bar{z}$ are outsourced. In this case, an increase in the budget does not affect the amount of outsourcing. Thus, if the examiner behaves so as to maximize examination quality, we will observe only a non-negative effect of outsourcing, since the outsourcing is chosen only when it will improve the examination quality. Therefore, we have the following hypothesis.

Hypothesis 1: Search scope is important at the margin

When an examiner behaves so as to maximize examination quality, an increase in the outsourcing due to a larger budget results in the quality improvement of examination (that is, smaller probability of making decision errors), if budgetary constraint is binding.

Then we consider the general case where the difference between l and v matters. In this case, the examiner will choose outsourcing if the expected cost of outsourcing is smaller than that of internal search: $c^i = l + p^i(z)\,\theta \geq c^o = v + p^o(z)\,\theta$. This condition can be rewritten as the following equation.

$$p^i(z) - p^o(z) \geq -(l - v)/\theta \quad (5)$$

Thus, the threshold of the complexity where the prior art is outsourced can be expressed as $\bar{z}'$ satisfying $p^i(\bar{z}') - p^o(\bar{z}') = -(l - v)/\theta$. This suggests that outsourcing can be chosen even if it increases the probability of making an examination error, when the examiner can reduce his private cost by outsourcing ($l - v > 0$) and the budget available for outsourcing (denoted by b') is binding but exceeds $\bar{z}$ ($\bar{z} \leq b' \leq \bar{z}'$) as shown in Figure 8. That is,

$$\partial E/\partial b' = -\{p^i(b') - p^o(b')\} < 0 \quad \text{if} \quad (l - v) > 0 \ \text{and} \ \bar{z} \leq b' \leq \bar{z}' \ . \quad (6)$$

In this case, we have the following Hypothesis 2.

Hypothesis 2: Synergy is important at the margin

If an examiner can save private cost by outsourcing and the budget for outsourcing exceeds the amount minimizing the probability of making decision errors, an increase in outsourcing due to an increase in budget constraint decreases the quality of examination (that is, larger probability of making wrong decisions).

There is a question of how the complexity of an examination task is related to the effect of outsourcing of prior art search. An increase in the complexity makes it more difficult for an examiner to understand the invention but it will also make his search scope narrower relative to the scope of the invention. Outsourcing can hinder the proper understanding of the complex invention, even though it helps expanding the search scope for identification of prior art. Thus, we have the following Hypothesis on the choice of outsourcing.

Hypothesis 3: Choice of outsourcing

If the complexity of the application enhances the benefit of deepening the understanding of the invention more than the benefit of widening the search scope, outsourcing will be less used for a complex application.

Outsourcing will also affect the communication period between the examiner and the applicant. Under the *search scope view*, relevant prior art is more likely to be identified through outsourcing. Therefore, it would generally result in more rapid final decisions, since an inclusive identification of relevant prior art helps to reach an early agreement on the evaluation of inventive step and the scope of the patent right. When the patent is being granted, the applicant will not maintain its request for a broader claim unjustified by the combination of the disclosure and prior art. Therefore, we will observe a shorter communication period for the patent application resulting in the grant decision. Similarly, if the examiner can present prior art convincingly denying the novelty of the invention, the applicant will not ask for a second look based on a revision of the patent application. Thus, under the *search scope view*, we can expect that outsourcing reduces the communication period.

Under the *synergy view*, outsourcing will reduce not only the efficiency of prior art search but also the examiner's understanding of the invention. The former effect on the communication period is likely to be positive. The latter effect on the communication period is however theoretically ambiguous. When an examiner underestimates the novelty of the invention due to poor understanding of prior art, the applicant will spend more time for making the examiner recognize that. Thus, the communication period can become longer. On the other hand, when the examiner overestimates the novelty of the invention, her decision is biased toward a grant decision which results in the shorter communication period.

Hypothesis 4: Effects on communication period

Under the search scope view, the effect of outsourcing on the length of the communication period is likely to be negative, while it is ambiguous under the synergy view.

4.2 Expected effects of the complexity of patent applications and the value of patenting

We expect that the more complex the examination task is, the more communication periods the applicants and examiners need. Furthermore, we expect that higher complexity of examination will decrease the quality of examination which would increase the frequency of appeals against the refusal decision. The effect of complexity of the examination task on the frequency of appeals for invalidation is not obvious, since the third parties may also face larger difficulty in bringing its appeal against the validity of the granted patents when the patent application is complex.

The value of patenting an invention can depend on the technical quality of the invention and the complementarity with the firm's complementary assets. When the value of patenting is high, the applicant has a stronger incentive to obtain a patent protection and to put more resources and time for that objective, as suggested by Harhoff and Wagner (2009). This will increase the communication period for a rejection and the frequency of appeals against refusal decisions. However, the effects of the value of patenting on the duration to the grant and on the frequency of the appeals for invalidation are ambiguous. Since the applicant invests more resources for getting a patent, the duration to the grant tends to be shorter when there is no basic disagreement between the applicant and the patent office. On the other hand, when a substantive disagreement exists and the value of patenting is high, the duration to the grant can become long, since the applicant does not easily give up patenting. If the latter effect is dominant, the duration to the grant becomes longer. A high value patent is less likely to have ground for invalidation since it is supported by high inventive step. However, the influence of such patent on the third party's business activity should be large, and thus the third party has more incentive to take an action for invalidating the patent for a given probability of success. If the latter effect dominates, high quality patent is more likely to be litigated.

Table 1 provides a summary of the expected effects of the outsourcing and the characteristics of the patent applications on the efficiency of examination when the outsourcing improves the quality of patent examination (under the *search scope view*).

[Table 1]

4.3 Estimation model

Our focus is on the effects of outsourcing on the efficiency of examination which we measure by the frequency of the appeals and the length of the communication period. Furthermore, we build an estimation model which accounts for the effects of the complexity of the examination task and the value of patenting of the invention on the quality and the duration of examination.

In order to assess the effects of outsourcing of prior art search on the variations of the performance indices, we take into account the endogeneity of outsourcing decision. As Hypothesis 3 suggests, an examiner is more likely to choose outsourcing when the search task is less complex, if the benefit of deepening the understanding of invention is large. At the same time, the examiner is less likely to make a mistake when the invention is not complex. Thus, the outsourcing decision is likely to be positively correlated with the examination performance, which however does not indicate the causal effect of outsourcing. In order to control for this endgogeneity bias, we employ two-stage least squares (2SLS) regression with instrumental variables, in addition to introducing the control variables measuring the complexity of an invention and the examiner fixed effect controlling for his capability and experience.

The estimation model of the second stage is represented by the following specification (7), and the model of the first stage is expressed by the selection equation (8). In order to assess the impact of endogeneity, we will show the results using a simple OLS method according to specification (7) in Appendix.

We can test the Hypotheses 1, 2 and 4 with the second stage estimation model (7) as well as the theoretical expectations shown in Table 1. We can also test the Hypothesis 3 with the first stage estimation model (8).

As for control variables, we introduce the measures representing the difficulty of an examination task, the value of patenting the invention for an applicant, the technological fields and the examiner specific factors (fixed effects). Our estimations are based on examination data of individual patent applications sorted by examination request month.

$$Y_{i,t} = \beta_1\ Outsource_{i,t} + \boldsymbol{\beta_2}\ Complexity_{i,t} + \boldsymbol{\beta_3}\ Value_{i,t} + \beta_4\ Ln\ IPCbacklog_{i,t} + \textstyle\sum_k \sum_j \sum_T \theta_{kjT} (Examiner_k * IPC_j * Year_T)\ + \varepsilon_{i,t}. \quad (7)$$

$$Outsource_{i,t} = \alpha_1\, outrate_{k,j,t-1} + \alpha_2\, IPCoutrate_{j\ni i,t-1}$$
$$+\boldsymbol{\alpha_3}\, Complexity_{i,t} + \boldsymbol{\alpha_4}\, Value_{i,t} + \alpha_5\, Ln\, IPCbacklog_{i,t}$$
$$+ \sum_k \sum_j \sum_T \lambda_{kjT}(Examiner_k * IPC_j * Year_T) + \epsilon_{i,t}. \quad (8)$$

In these specifications, i denotes the examined patent application and t denotes the examination request date (monthly time). The vectors $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$, $\boldsymbol{\theta}$ and $\boldsymbol{\lambda}$ are the coefficient parameters.

Considering the potential correlation between variable $outsource_{i,t}$ and error term $\varepsilon_{i,t}$ in equation (7), we implement an instrumental variables estimation as specified by equation (8). Let k and j denote an examiner and an IPC class for application i requested for an examination in t. As instrumental variables, we use the lagged ratio of outsourcing by examiner k in IPC class j ($outrate_{k,j,t-1}$), and the lagged IPC-level overall ratio of outsourcing of all examiners except examiner k in IPC class j ($IPCoutrate_{j\ni i,t-1}$).

Examiner k's decision on outsourcing for the applications requested for examinations in period $t-1$ do not directly affect the examination performance for the applications requested for examinations in period t, since they are independent applications. Since an examiner is ultimately responsible for prior art search, even if it is outsourced, the examiner's learning from examination is not significantly affected by outsourcing per se, especially when we focus on a relatively short time interval. Similarly, the change in the rate of outsourcing of other examiners is also unrelated to the performance of that examiner. On the other hand, the decision on outsourcing in period $t-1$ would be highly correlated with the outsourcing rate of that examiner in period t, due to the rigidity or inertia of budgetary or the other resource allocations for outsourcing. Similarly, an increase in the outsourcing of other examiners due to the increase in the budgetary or the other resource allocation to a certain IPC class will enable more outsourcing of any examiner in the same field.

As dependent variables ($Y_{i,t}$), we use the length of the communication period which is the monthly duration between an examiner's first action and its final decision, and the dummy variables reflecting the occurrence of the appeals. The reason why we use the communication period, not the examination duration, is that our focus is on the length between the starting date and the ending date of examination. That is, the length of the first action period (between the examination request and the first action) depends mainly on the backlog and does not reflect the actual examination task. We also differentiate the effects on the eventually refused applications and eventually granted applications.

Our main focus is on the coefficient of the independent variable $outsource_{i,t}$ in the second stage estimation (7). This variable is the dummy variable which set to one if the examiner outsourced the prior art search for its examination.

Moreover, we focus on the characteristics of applications in terms of following two aspects; (A) the complexity of the examination task ($Complexity_{i,t}$), and (B) the value of patenting the invention ($Value_{i,t}$). Harhoff and Wagner (2009) found that the accelerated examination and the number of backward citations have significant effect on examination duration. We confirm this finding, using the Japanese patent examination data.

In this paper, as an index of the complexity of the examination task and the scope of invention, we use the number of claims ($numclaim_{i,t}$), the number of IPCs ($numIPC_{i,t}$), the number of inventors ($numinventor_{i,t}$) in an application, and the dummy variable reflecting whether the patent application is an international application through Patent Cooperate Treaty ($PCT_{i,t}$) and the number of inventor citations ($numinvcite_{i,t}$).

We measure the value of patenting of an invention by the dummy variable set to one if the application is submitted for accelerated examination ($accelerated_{i,t}$), and the number of forward citations by either applicant or examiner ($forward_{i,t}$). Only the patent applications which have been disclosed can be outsourced. Thus, the prior art search for the applications requesting early examinations are less likely to be outsourced.

In order to control for the impact of the changes in the magnitude of backlog in each technological field on the length of communication period and on the examination quality, we introduce the IPC class level (3 digits) backlog variable $Ln\,IPCbacklog_{i,t}$. The variable $Ln\,IPCbacklog_{i,t}$ is the logarithm of the total number of examination requests in the IPC class where application i is filed. This variable controls for the changes in the workloads of examiners and the needs for outsourcing across the technological fields. An increase in backlog would result in more efforts of the Patent Office to reduce the length of the communication period, and thereby prevent significant increase in the total length of the examination period. At the same time, more demand for outsourcing may reduce the marginal opportunity for an application to be outsourced, if the available supply of external experts on prior art search is limited. These effects would induce a spurious positive correlation between outsourcing and the performance variables. Moreover, we include the cross term of examiner fixed effect denoted by $examiner_k$, IPC dummies denoted by IPC_j and year dummies denoted by $reqyear_T$. The 3 digits IPC-class include 121 technological fields.

These control variables aim at removing the spurious correlations between outsourcing and examination performance and the truncation bias. One potential source of such endogeneity is the possibility that a capable and experienced examiner, whose examination performance is high, can exploit outsourcing more effectively. Another potential source is that both examination performance and ease of outsourcing might be high in the technology areas where prior art can be clearly identified. We use the final decision year dummies as time dummies for the estimation on the occurrence of appeals while we use the first action year dummies for the estimation on the communication period so that we can control for the truncation bias as well as the time trend.

The descriptive statistics used in the estimations are summarized in Table 2.

[Table 2]

5 Estimation results

Table 3 shows the results of 2SLS estimations when we use the occurrence of appeals as dependent variables. We provide, in Table 4, the results with the communication periods as dependent variables. These tables provide the results of subsamples of the eventually refused applications and the eventually granted applications, respectively.

5.1 Choice of outsourcing of prior art search

First, looking at the results of the first stage estimation in Table 3 and 4, the coefficients of instrumental variables are positive and significant. Therefore, we can confirm that the examiner's use of outsourcing has inertia and depends on the budgetary constraint allocated to a certain technology field. These instrumental variables work well.

As for the other determinants, we find that the coefficients of the complexity indices except for the number of inventor citations are negative and statistically significant in all estimation models. More specifically, the number of claims, the number of IPCs, the number of inventors and the PCT application dummy have significantly negative effects on the examiner's decision on using outsourcing. These results suggest that an examiner uses outsourcing more actively when the search task is less complex. This supports the Hypothesis 3, indicating the relative importance of the verification cost for the high complex inventions. The number of inventor citations can reflect the easiness of identifying the prior art. Thus, this variable could have inverse relation with the novelty and inventiveness of inventions and the verification cost.

The fact that the complexity has statistically significant effects also suggests that the simple OLS estimation can overestimate the effect of outsourcing on the examination performance.

We can also confirm that outsourcing is significantly less used when there is a request for accelerated examination, consistently with the JPO practice.

5.2 Effects on the quality of examination

The results in Table 3 provide clear evidence that the increase in the outsourcing increases the quality of examination. Outsourcing has significant negative effects on the occurrences of appeals against both types of decisions, though the significance is relative small for the patent invalidation because of the low frequency. According to the results, the probability of occurrence of appeal against the refusal decision decreases by about 49% point (the mean is 7.9%), and that of appeal for the patent invalidation decreases by about 70% (the mean is 0.12%) if the prior art search is outsourced. These changes are substantial.

Considering the results that the outsourcing is more frequently used for the inventions with low complexity, our results can support the Hypothesis 1 for the inventions with low complexity and can support the Hypothesis 2 for the inventions with high complexity. This indicates that giving an examiner an option for outsourcing is crucial to improve the quality of examination.

We expect that the increase in the complexity of examination task increases the frequency of appeals against the refusal decision, since it becomes a source of the discrepancy of the views on the patentability between examiners and applicants due to the difficulty of identifying relevant prior art, as shown in Table 1. The results in Table 3 support this expectation.

The complexity of examination task is expected to have an ambiguous effect on the frequency of appeals for invalidation in Table 1, since it also increases the difficulty for third parties to question the grant decision. Table 3 shows that the statistical significances for the variables of complexity are low, which reflect this mutually opposite effects.

Table 3 also shows that high value of patenting, measured by the use of accelerated examination system and the frequency of forward citations, increases the appeals against refusals, as expected in Table 1. Both variables are also found to have positive effects on the appeals against grants. These results suggest that third parties challenge high value patents more than low value patents for invalidations even if the probability of the success of such challenge is small, perhaps because the relative benefit of challenge is larger for the high value patents.

The effects of accelerated examinations as estimated in Table 3 allow an interpretation, other than the fact that the applications requested for early examinations tend to have high values. From the examiner’s viewpoint, apart from the regular first-in first-out procedure, changing the order of examinations in responding to the applicant’s request could cause the inefficiency of examination process. Changing the order of the tasks forces the examiner to adjust the patentability standard by adopting new priority dates for examinations. This reduces the quality of examination, which could result in high frequency of appeals for both decisions.

[Table 3]

5.3. Effects on the length of the communication period

In Table 4, the coefficients of the variable $outsource_{i,t}$ are significantly negative in all estimation models. This suggests that outsourcing reduces the necessity of communication between the examiner and the applicant, which leads to the reduction of the length of examination duration. This result shows the large benefit of outsourcing in identifying the convincing prior art.

We find that higher complexity of examination prolongs the communication period, as expected in Table 1. More specifically, the numbers of claims, the number of IPCs, the number of inventors and the number of references have positive effects on the length of the communication period in the estimations based on the total sample[9]. PCT applications also have longer communication period, which is consistent with the fact that they tend to include advanced technology and an examiner often has to understand them with translated documents. These results suggest that the examiners and applicants need more communications to establish a common knowledge ground for assessing complex applications.

Table 4 also shows that a more complex examination task results in longer communication period for both refusals and grants, except for the effect of the number of inventor citations.

We expect that higher value of patenting has a positive effect on the communication period for the eventually refused applications, while the effect is ambiguous on the eventually granted applications, from Table 1. This expectation is supported by the results. Both of $acceralate_{i,t}$ and $forward_{i,t}$ have positive effects on the length of the communication period for the eventually refused applications. On the other hand, not surprisingly, the coefficients of $acceralate_{i,t}$ are negative for the eventually granted applications since they are on the fast truck though the statistical significance is low. The above results suggest that an applicant has an incentive to persistently fight against the reasons for refusal when the invention includes important technological contributions and the value of patenting is high.

The backlog variable at IPC levels has a significant effect but its inclusion does not significantly affect the coefficients of the other explanatory variables. In particular, an increasing backlog over time is associated with a shorter communication period, which may indicate the effort of the patent office to reduce the backlog.

[Table 4]

5.4 Effects of endogeneity of selections

In Appendix, we show the results of OLS estimations, to assess the effects of endogenous selection of outsourcing. The signs of all independent variables are the same with the results of

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9 The number of references has negative effects when we use the subsamples of the eventually refused applications and the eventually granted applications, though the coefficient is positive in the estimation based on the pooled data. This is due to the composition effect that the number of references has larger effect on the granted applications that have longer communication period than the refused applications.

2SLS estimations. However, the magnitude of the effect of outsourcing is much larger with OLS results. This suggests that two-stage estimations correct the overestimation of the effect of outsourcing, due to an endogenous selection of outsourcing.

The likely source of such endogeneity is that less complex patent applications are more frequently outsourced. At the same time, the coefficients of outsourcing are significant, even after controlling for this endogeneity.

6. Conclusions

The global surge of patent application causes a great concern not only about the increasing backlog of pending patent applications in many countries, but also the quality of examination. The increasing complexity of inventions also aggravates the problem. Under these circumstances, the improvement of the efficiency of examination process has been recognized as an urgent task. Outsourcing of prior art search is one promising solution. Outsourcing may increase examination quality by expanding the scope of prior art search, while it may also reduce the quality by weakening the synergy between search and examination. This paper empirically assesse the determinants of the efficiency of patent examination, with a central focus on the effect of outsourcing of prior art search. We use a large scale patent examination data in Japan, involving more than 1.6 million applications requested for examinations from 1996 to 2007 for our econometric exercises.

There are two offsetting effects of outsourcing. Outsourcing enables an examiner to take advantage of the search ability of the searchers specialized in prior art identification so that the potential search scope can be expanded. On the other hand outsourcing can hamper the synergy between search and examination. If examination quality is the predominant concern of an examiner for the choice of an outsourcing decision and the outsourcing is constrained by budgetary resources, we expect that an increase in outsourcing enhances examination quality at its margin. On the other hand, if an examiner can save private cost by outsourcing and the budget for outsourcing exceeds the amount minimizing the probability of making decision errors, an increase in outsourcing decreases the quality of examination

Our estimation results show that the increase in the outsourcing of prior art search significantly increases not only the speed but also the quality of examination. We find that the increase in the outsourcing decreases the probability of appeals against refusal decision by 49.7%, and it also reduces the probability of appeals for patent invalidation by 70.0%. These results indicate a large benefit of outsourcing on the efficiency of patent examination. Exploiting the knowledge of the outside searcher specialized in prior art identification improves the quality of examination, since identifying the adequate prior art is a vital step in the patent examination process.

Our study does not suggest that all of prior art search should be outsourced. We provide the evidence that integration is chosen for complex patent applications, which indicates the existence of an inherent advantage of integrating search and examination. Our results, therefore, simply suggest that creating the opportunities for "make" and "buy" choice with respect to prior art search can significantly improve the quality and speed of patent examination.

In these assessments of the effects of outsourcing, we controlled for the endogeneity of using the outsourcing, the complexity of examination task for each patent application and the value of patenting an invention. We confirmed that more complex patent applications and higher value of patenting resulted in longer communication period for both grants and for rejections, consistent with earlier related studies. We also found new evidence that more complex inventions were involved in more appeals against rejections and in fewer appeals against grants, while higher value of patenting resulted in more appeals against both decisions.

There are important remaining research issues. One is the negative effects of accelerated examination system on the efficiency of patent examination. Our results allow two interpretations. One is simply that the patent application requested for accelerated examination has high value, and thus the applicant put more efforts for patenting. This lengthens the period to rejection and increases the frequency of appeals. Another interpretation is the effect through stronger informational constraint on examining the applications submitted to accelerated examination. If the latter effect is more important, our results imply the necessity of consideration on the tradeoff between the applicant's need for early protection and the efficiency of examination process, when we design optimal examination system. Clarifying these mechanisms requires another research.

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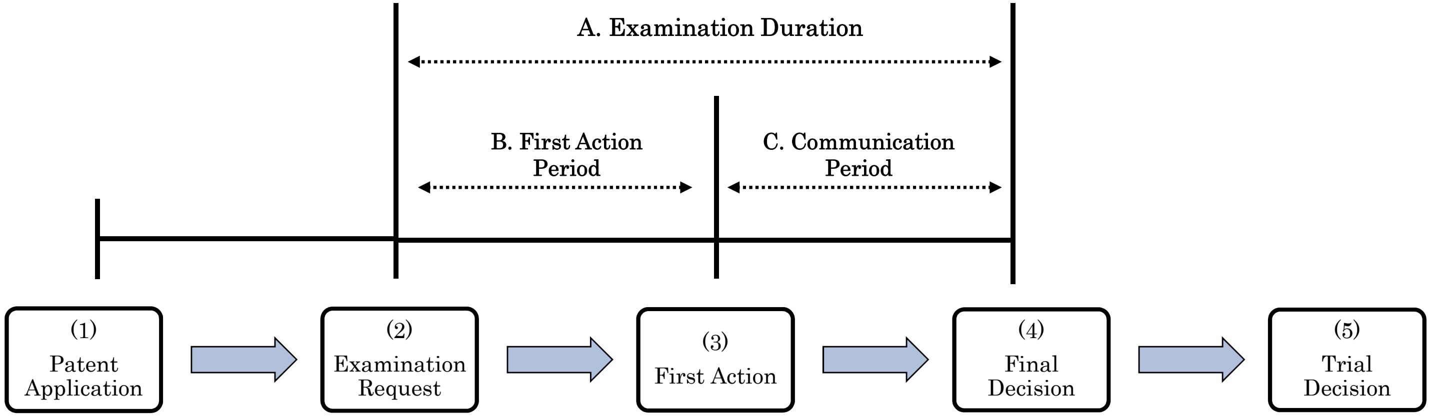
Figure 1. Definition of examination duration



Applicant	Request / Withdraw		Argument / Amendment / Withdraw		Appeal against Decision of Refusal
Examiner		Notification of Reasons for Refusal / Grant		Refusal / Grant	

Figure 2. Outsourcing rate

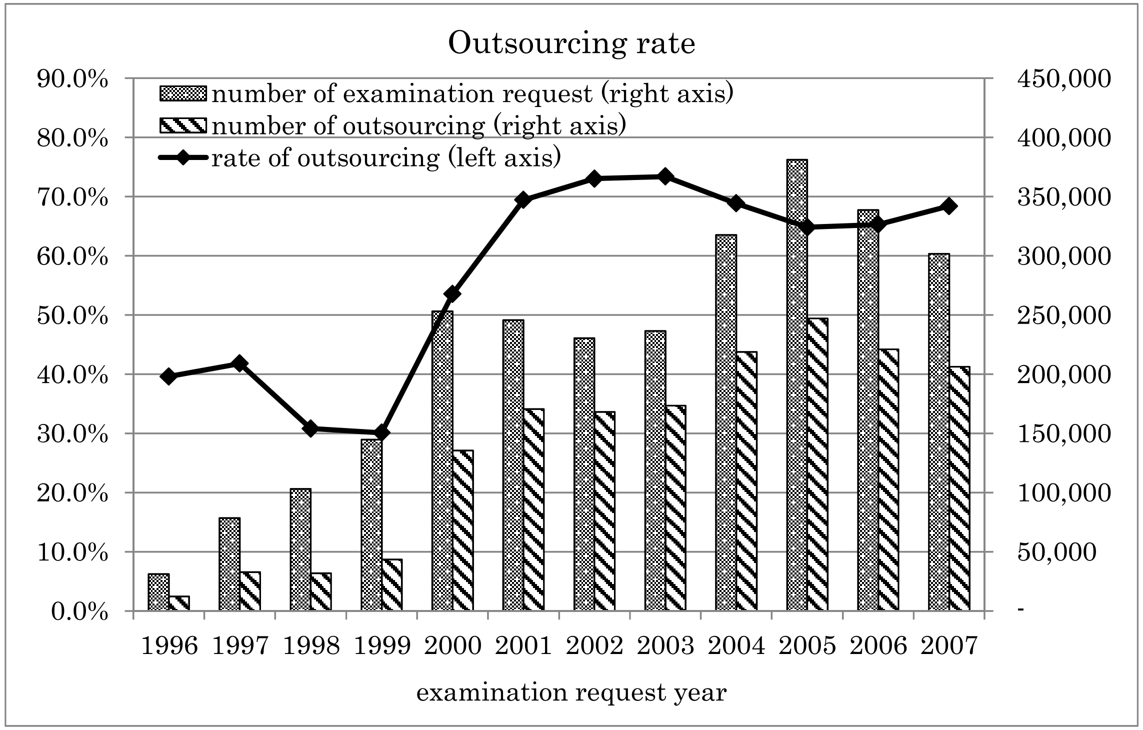


Figure 3. Appeal rate to the refusal decision

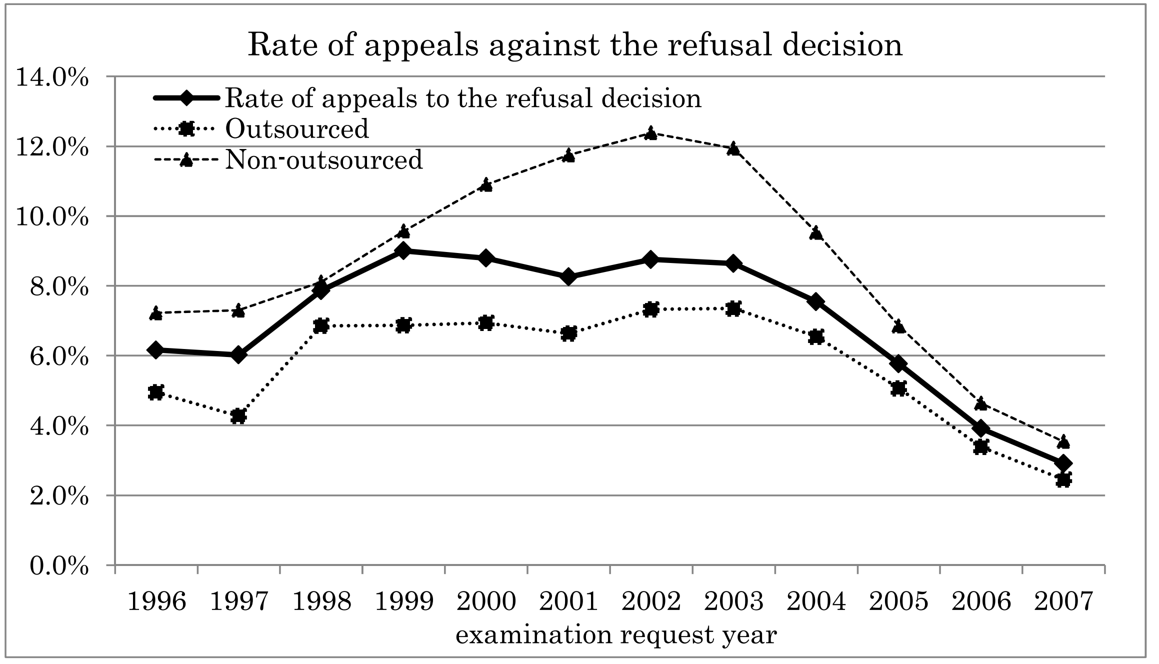


Figure 4. Appeal rate to the grant decision

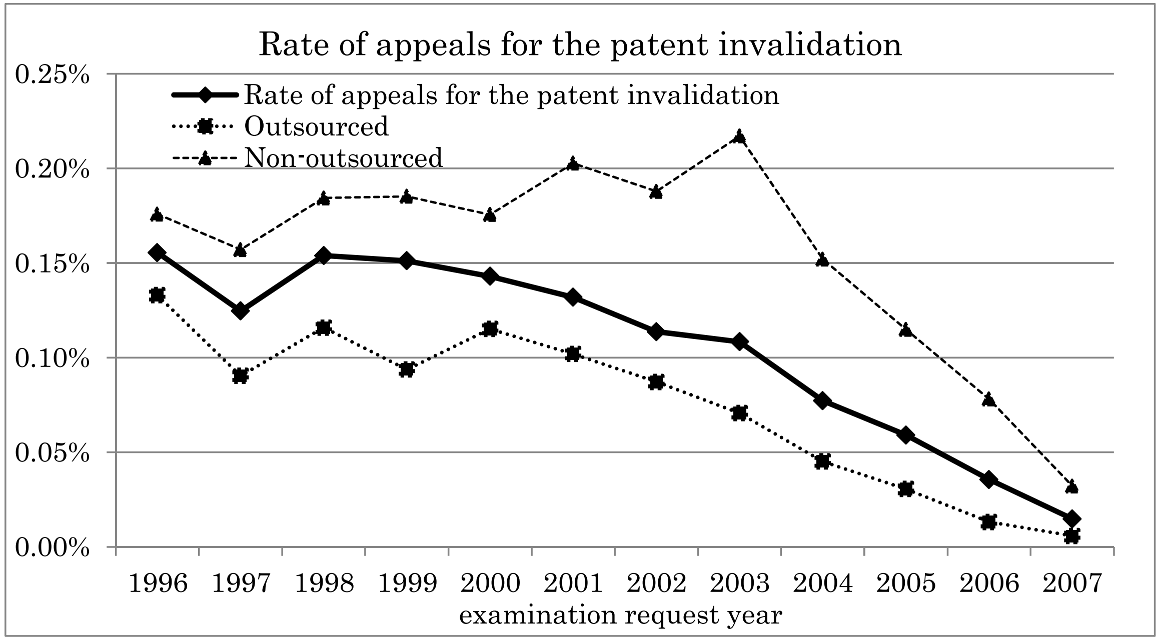


Figure 5. Examination duration

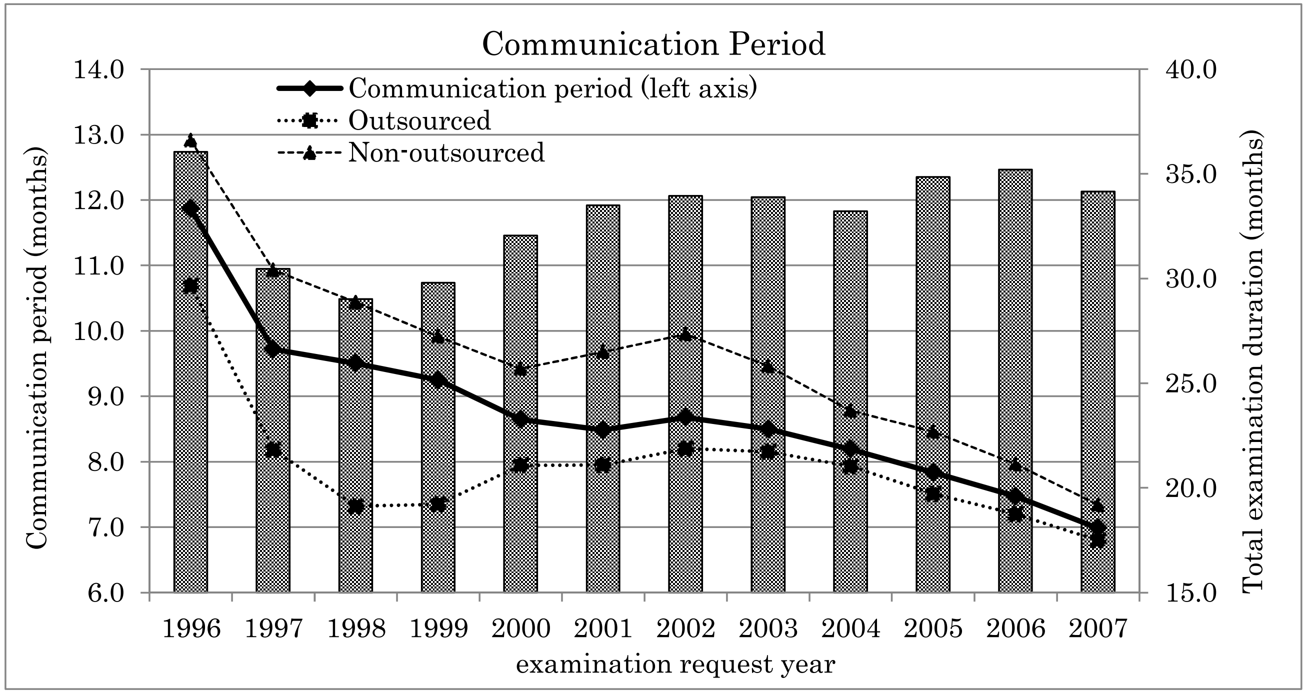


Figure 6. Characteristics of examined applications

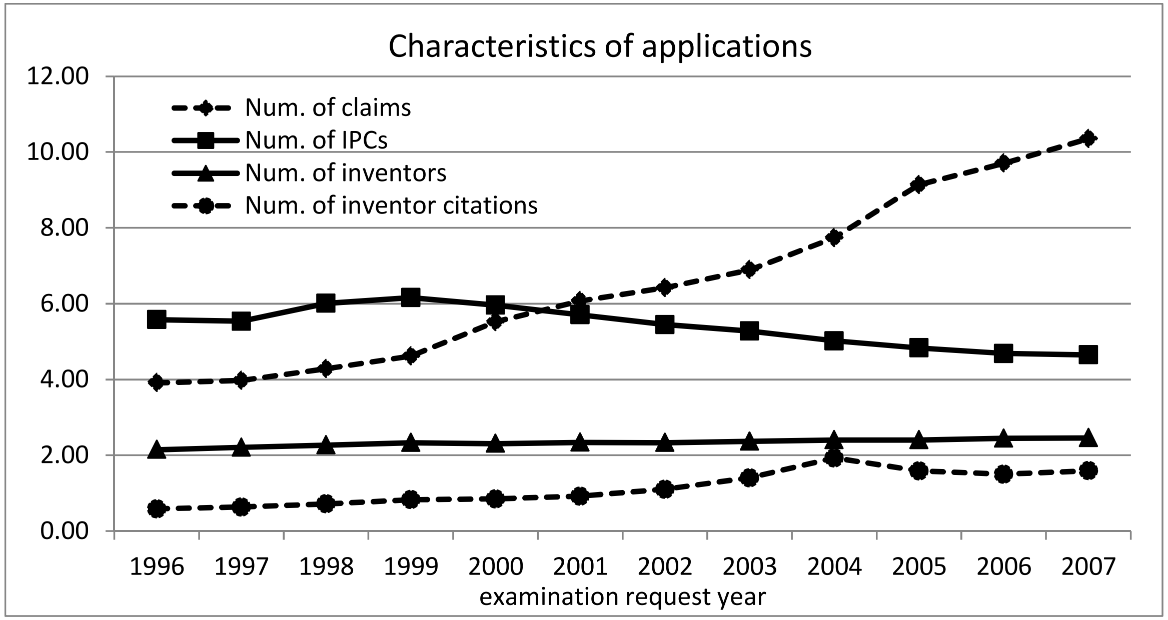


Figure 7. Applicants' needs for early patent protection

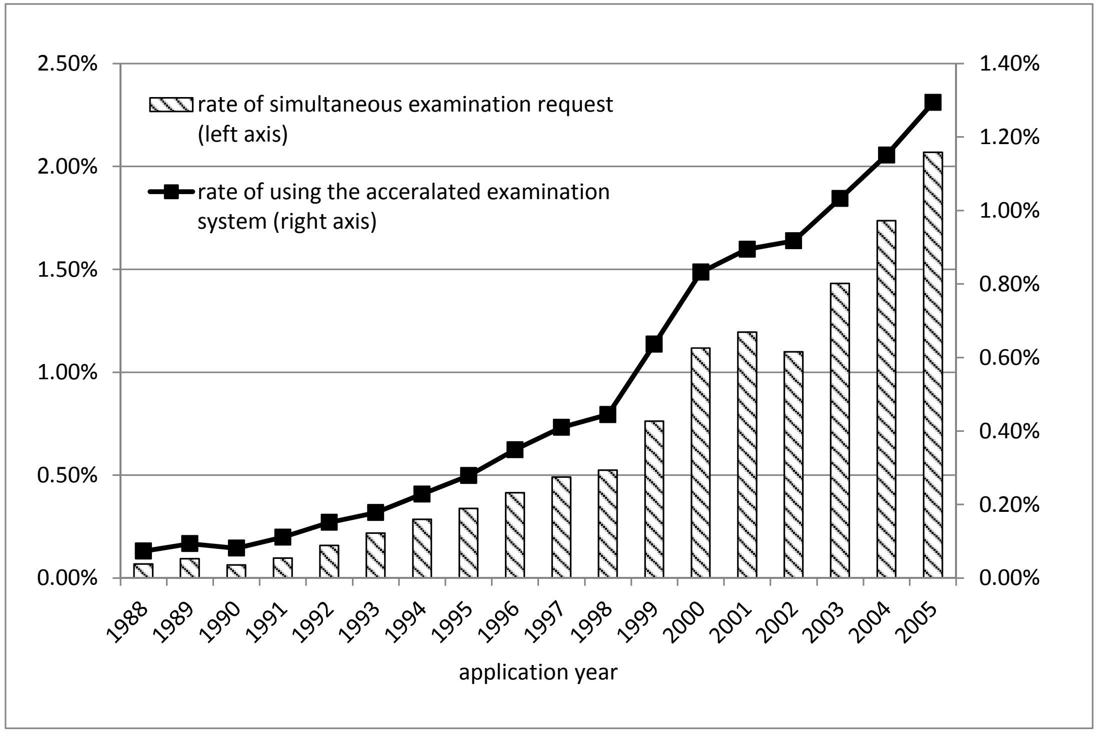


Figure 8. Choice of outsourcing by an examiner

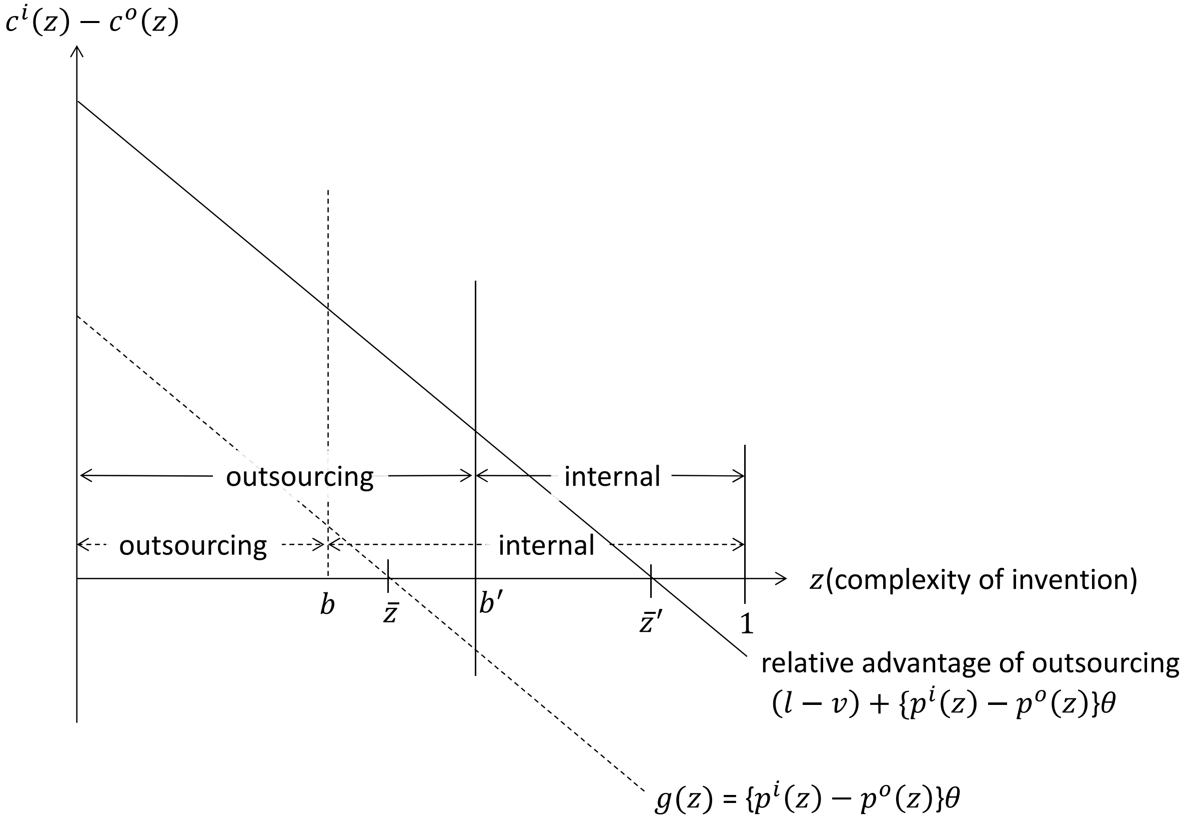


Table 1. Expected signs of determinants of the examination outcomes

	Frequency of appeals		Communication Period		
	against refusal	for invalidatoin	Total	refusal	grant
Outsourcing of prior art search					
under the search scope view	-	-	-	-	-
under the synergy view	+	+	?	?	?
Complexity of the examination task	+	?	+	+	+
Value of patenting	+	?	+	+	?

Table 2. Descriptive statistics

	Variables	Observations	Mean	SD	Min	Max
Dependent variables	*Communication period (for whole applications)*	1667671	8.700	7.566	0	123
	Communication period (for refused applications)	753624	6.858	5.417	0	112
	Communication period (for granted applications)	797999	8.597	5.961	1	70
	Occurance of appeal against the decision of refusal	771958	0.079	0.270	0	1
	Occurance of appeal for patent invalidation	1007382	0.0012	0.035	0	1
Independent variables	*outsource*	1900807	0.601	0.490	0	1
	numclaim	1900807	7.292	9.328	1	999
	numIPC	1900807	5.877	8.372	1	1071
	numinventor	1900807	2.423	1.676	1	42
	PCT	1900807	0.082	0.275	0	1
	numinvcite	1900807	1.329	4.191	0	2422
	accelerated	1900807	0.013	0.112	0	1
	forward	1900807	1.439	2.028	0	262
	Ln IPCbacklog	1682253	0.593	0.336	0.00	1.00
	$outrate_{k,j,t-1}$	1680988	0.567	0.208	0	1
	$IPCoutrate_{j,t-1}$	1900807	6.230	1.178	0.69315	8.40827

Table 3. Effects on the frequency of appeals

	Occurance of Appeals							
	against the refusal decision				for patent invalidation			
	Second stage		First stage: *outsource*		Second stage		First stage: *outsource*	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
outsource	-0.039***	-0.040***			-0.00085*	-0.00086*		
	(-9.71)	(-10.09)			(-1.90)	(-1.92)		
outrate $_{k, j, t-1}$			0.325***	0.325***			0.32815***	0.32837***
			(149.51)	(149.72)			(166.47)	(166.59)
IPCoutrate $_{j, t-1}$			0.295***	0.295***			0.24136***	0.24177***
			(58.27)	(58.27)			(56.35)	(56.44)
numclaim	0.001***	0.001***	-0.002***	-0.002***	0.00000	0.00000	-0.00350***	-0.00350***
	(19.93)	(19.76)	(-40.12)	(-40.07)	(0.34)	(0.34)	(-64.49)	(-64.56)
numIPC	0.000***	0.000***	-0.001***	-0.001***	-0.00001	-0.00001	-0.00041***	-0.00041***
	(4.93)	(5.17)	(-10.20)	(-10.34)	(-1.51)	(-1.51)	(-7.73)	(-7.75)
numinventor	0.005***	0.005***	-0.002***	-0.002***	-0.00008***	-0.00008***	-0.00254***	-0.00254***
	(22.23)	(22.19)	(-8.28)	(-8.27)	(-3.41)	(-3.41)	(-9.91)	(-9.90)
PCT	0.057***	0.057***	-0.373***	-0.373***	0.00006	0.00007	-0.42002***	-0.42066***
	(27.45)	(27.63)	(-191.51)	(-191.97)	(0.25)	(0.27)	(-232.35)	(-232.88)
numinvcite	0.000**	0.000**	0.001***	0.001***	-0.00000	-0.00000	0.00099***	0.00100***
	(2.22)	(2.04)	(7.76)	(7.86)	(-0.54)	(-0.55)	(10.07)	(10.21)
accelerated	0.306***	0.303***	-0.500***	-0.498***	0.01234***	0.01232***	-0.51224***	-0.51088***
	(64.18)	(63.54)	(-83.16)	(-82.87)	(32.02)	(32.03)	(-144.51)	(-144.25)
forward	0.009***	0.009***	0.003***	0.003***	0.00037***	0.00037***	0.00138***	0.00137***
	(44.87)	(44.96)	(11.57)	(11.53)	(20.86)	(20.87)	(6.91)	(6.87)
Ln IPCbacklog	-0.030***		0.022***		-0.00021		0.01655***	
	(-20.45)		(10.83)		(-1.28)		(8.98)	
*Eexaminer*IPC*Year*	yes	yes	yes	yes	yes	yes	yes	yes
Observations	683,429	683,429	683,429	683,429	890,540	890,540	890,540	890,540
R-squared			0.121	0.120			0.134	0.134
Number of exipcfirstyea	32,513	32,513	32,513	32,513	33,329	33,329	33,329	33,329

z-statistics and t-statistics in parentheses

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

Table 4. Effects on the communication period

	Communication Period											
	Total				Refusal decisions				Grant decisions			
	Second stage		First stage: *outsource*		Second stage		First stage: *outsource*		Second stage		First stage: *outsource*	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
outsource	-0.676***	-0.681***			-0.728***	-0.733***			-0.502***	-0.512***		
	(-8.00)	(-8.08)			(-8.44)	(-8.52)			(-5.81)	(-5.93)		
outrate $_{k, j, t-1}$			0.282***	0.282***			0.288***	0.289***			0.279***	0.279***
			(187.37)	(187.68)			(131.11)	(131.43)			(124.79)	(124.91)
IPCoutrate $_{j, t-1}$			0.193***	0.193***			0.215***	0.216***			0.173***	0.173***
			(55.23)	(55.32)			(41.64)	(41.73)			(33.93)	(33.97)
numclaim	0.043***	0.043***	-0.003***	-0.003***	0.033***	0.033***	-0.002***	-0.002***	0.045***	0.045***	-0.003***	-0.003***
	(62.40)	(62.40)	(-72.72)	(-72.77)	(46.36)	(46.35)	(-39.94)	(-39.94)	(60.29)	(60.27)	(-59.09)	(-59.12)
numIPC	0.004***	0.004***	-0.000***	-0.000***	0.011***	0.011***	-0.001***	-0.001***	0.008***	0.008***	-0.000***	-0.000***
	(5.73)	(5.73)	(-7.11)	(-7.15)	(12.63)	(12.64)	(-10.66)	(-10.75)	(11.51)	(11.52)	(-5.52)	(-5.53)
numinventor	0.113***	0.113***	-0.003***	-0.003***	0.079***	0.079***	-0.002***	-0.002***	0.040***	0.040***	-0.003***	-0.003***
	(32.58)	(32.58)	(-14.36)	(-14.32)	(21.24)	(21.23)	(-7.98)	(-7.94)	(11.83)	(11.82)	(-9.83)	(-9.83)
PCT	3.762***	3.762***	-0.377***	-0.377***	2.996***	2.996***	-0.365***	-0.366***	3.508***	3.508***	-0.397***	-0.398***
	(94.60)	(94.60)	(-293.63)	(-294.15)	(73.33)	(73.35)	(-187.92)	(-188.31)	(84.08)	(84.07)	(-210.48)	(-210.73)
numinvcite	0.032***	0.032***	0.001***	0.001***	-0.007***	-0.007***	0.001***	0.001***	-0.013***	-0.013***	0.001***	0.001***
	(22.86)	(22.83)	(9.17)	(9.41)	(-3.51)	(-3.53)	(8.57)	(8.72)	(-10.49)	(-10.58)	(7.04)	(7.15)
accelerated	-0.521***	-0.530***	-0.505***	-0.503***	0.129	0.120	-0.508***	-0.505***	-2.733***	-2.750***	-0.511***	-0.510***
	(-7.71)	(-7.87)	(-174.26)	(-173.68)	(1.46)	(1.36)	(-86.64)	(-86.15)	(-42.52)	(-42.90)	(-133.95)	(-133.75)
forward	0.156***	0.156***	0.002***	0.002***	0.084***	0.084***	0.003***	0.003***	0.037***	0.037***	0.002***	0.002***
	(55.64)	(55.65)	(12.37)	(12.38)	(24.54)	(24.54)	(9.99)	(10.01)	(14.29)	(14.29)	(7.30)	(7.30)
Ln IPCbacklog	-0.079***		0.024***		-0.065**		0.031***		-0.160***		0.016***	
	(-3.08)		(17.07)		(-2.42)		(15.43)		(-6.28)		(7.48)	
*Eexaminer*IPC*Year*	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,474,552	1,474,552	1,474,552	1,474,552	667,175	667,175	667,175	667,175	705,298	705,298	705,298	705,298
R-squared			0.117	0.117			0.109	0.109			0.126	0.126
Number of exipcfirstyeai	35,139	35,139	35,139	35,139	30,593	30,593	30,593	30,593	31,497	31,497	31,497	31,497

z-statistics and t-statistics in parentheses

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

Appendix. Results of OLS estimations

	Occurance of Appeals				Communication period					
	against the refusal decision		for patent invalidation		Total		Refusal decisions		Grant decisions	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
outsource	-0.0162***	-0.0166***	-0.00067***	-0.00068***	-0.961***	-0.962***	-0.817***	-0.818***	-0.601***	-0.602***
	(-19.68)	(-20.09)	(-7.53)	(-7.54)	(-68.33)	(-68.41)	(-53.36)	(-53.46)	(-43.22)	(-43.30)
numclaim	0.0008***	0.0008***	0.00001	0.00001	0.043***	0.043***	0.033***	0.033***	0.045***	0.045***
	(23.39)	(23.25)	(1.62)	(1.63)	(69.32)	(69.32)	(51.37)	(51.36)	(69.75)	(69.78)
numIPC	0.0003***	0.0003***	-0.00001	-0.00001	0.005***	0.005***	0.012***	0.013***	0.009***	0.009***
	(5.80)	(6.11)	(-1.47)	(-1.47)	(7.09)	(7.10)	(14.73)	(14.75)	(13.11)	(13.12)
numinventor	0.0046***	0.0046***	-0.00009***	-0.00009***	0.110***	0.110***	0.077***	0.077***	0.038***	0.038***
	(23.29)	(23.28)	(-4.02)	(-4.02)	(33.61)	(33.60)	(21.84)	(21.83)	(11.76)	(11.76)
PCT	0.0663***	0.0672***	0.00012	0.00013	3.671***	3.673***	2.989***	2.991***	3.463***	3.466***
	(48.83)	(49.54)	(0.76)	(0.80)	(162.89)	(163.01)	(120.95)	(121.03)	(154.19)	(154.38)
numinvcite	0.0002*	0.0002*	-0.00001	-0.00001	0.033***	0.033***	-0.006***	-0.006***	-0.014***	-0.014***
	(1.93)	(1.72)	(-0.76)	(-0.78)	(24.30)	(24.26)	(-3.33)	(-3.36)	(-11.74)	(-11.85)
accelerated	0.3154***	0.3124***	0.01353***	0.01352***	-0.622***	-0.630***	0.101	0.092	-2.747***	-2.761***
	(78.61)	(77.86)	(46.05)	(46.05)	(-12.75)	(-12.94)	(1.42)	(1.29)	(-63.24)	(-63.62)
forward	0.0085***	0.0085***	0.00035***	0.00035***	0.158***	0.158***	0.083***	0.083***	0.038***	0.038***
	(46.69)	(46.79)	(20.34)	(20.35)	(59.54)	(59.54)	(25.62)	(25.62)	(15.28)	(15.28)
Ln IPCbacklog	-0.0311***		-0.00015		-0.089***		-0.083***		-0.158***	
	(-22.90)		(-1.00)		(-3.73)		(-3.33)		(-6.61)	
*Eexaminer*IPC*Year*	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	771,948	771,948	1,007,376	1,007,376	1,667,671	1,667,671	753,624	753,624	797,999	797,999
R-squared	0.020	0.019	0.003	0.003	0.034	0.034	0.043	0.043	0.056	0.056
Number of fixed effects	42,164	42,164	46,060	46,060	53,692	53,692	40,469	40,469	42,906	42,906

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