



RIETI Discussion Paper Series 10-E-049

# **Incentive Pay or Windfalls: Remuneration for employee inventions in Japan**

**ONISHI Koichiro**

Faculty of Intellectual Property, Osaka Institute of Technology

**OWAN Hideo**

Institute of Social Science, The University of Tokyo



Research Institute of Economy, Trade & Industry, IAA

The Research Institute of Economy, Trade and Industry  
<http://www.rieti.go.jp/en/>

## Incentive Pay or Windfalls: Remuneration for Employee Inventions in Japan

Koichiro Onishi  
Faculty of Intellectual Property, Osaka Institute of Technology  
Hideo Owan  
Institute of Social Science, The University of Tokyo

### Abstract

This paper summarizes historical developments in Japan's legal treatment of firms' invention remuneration policies and examines the impact of such policies on R&D performance using original data from surveys including the 2005 IIP Invention Remuneration Survey, the 2007 RIETI Inventor Survey and its 2008 follow-up survey. Tracking the linkages between remuneration policy and R&D performance is complicated by Japanese firms' reluctance to reveal the details of their policies to their employees before the 2004 amendment of Japan's *Patent Law*. By matching the data from firm-level and individual-level surveys, we find that nearly 40% of inventors believed that their firms did not have revenue-based remuneration although their employers reported they actually had instituted such policies. We estimate the effect of revenue-based remuneration policies on R&D performance using two policy variables for the incidence of contingent remuneration policies, one of which depends on the firms' responses and the other on individual employees' survey responses. Our project-level or patent-level productivity measures include the number of patents generated from a project, inventors' subjective evaluation of their patents' economic value, and indicators of whether the patent was used commercially. After taking measures to eliminate estimation bias, such as the propensity score matching method and instrumental variable estimation, we find no evidence that the prospect of greater monetary compensation is affecting the quantity or quality of patents or the likelihood of their commercialization except for a sample of those who rated the importance of monetary rewards as "not unimportant", from whom we obtain weak evidence of the real impact of monetary incentives.

Key words: patent, invention, incentives, intrinsic motivation, multi-tasking, commercialization  
JEL classification: J33, M52, O31, O34

RIETI Discussion Papers Series aims at widely disseminating research results in the form of professional papers, thereby stimulating lively discussion. The views expressed in the papers are solely those of the author(s), and do not present those of the Research Institute of Economy, Trade and Industry.

The authors are grateful for helpful comments and suggestions by Sadao Nagaoka, Bronwyn Hall, Katsuyuki Kubo, Yosuke Okada, Jun Suzuki, Tetsuo Wada and seminar participants at the University of Tokyo, and the Research Institute of Economy, Trade and Industry.

## Introduction

The 2004 amendment of Section 35 of Japan's *Patent Law* caused many Japanese firms to revise their remuneration policies for employee inventions and boost payouts to inventors. The most significant change, however, was the firms' decision to greatly increase the disclosure of their policies to employees. A director of the intellectual property rights office of a Japanese electronic machinery manufacturer said:

*"In 2005 when the law was revised, we held a series of meetings to explain our remuneration policy for employees' inventions to all employees. We were given a roster of all employees and checked their attendance and, if necessary, arranged one-to-one meetings to make sure that everyone received an explanation. Since the law requires "consultation" with the employees, we created a special email address to receive their inquiries and comments. Since 2005, we have held an information session for new employees every year including a 30-page PowerPoint presentation that explains the Patent Law, describes the legal treatment of employees' inventions, and provides a detailed explanation of the formulae used to determine remuneration levels. Furthermore, all the information including the formal provisions and a two-page summary is available for viewing on our intranet, therefore anyone can see it whenever they want."*

Before the amendment, as we show later, many firms did not reveal the details of their remuneration policies to employees. Since many inventor-employees did not precisely know whether or how much remuneration they would receive prior to developing their inventions, it is conjectured that many employee-inventors perceived remuneration as windfalls. Employees' uncertainty regarding payouts blurred the relationship between monetary incentives and inventive productivity in the pre-amendment period because compensation policy should have an impact only when rewards are anticipated. Although it is quite clear that judicial decisions provided the impetus to amend the

*Patent Law*, the amendment's impacts on inventor behavior, inventive efforts, and productivity are less obvious for these reasons.

The purpose of the paper is to explain what led to the amendment of the law, to discuss why there has been a tendency to downplay the role of invention remuneration, and to explore what kinds of effects the invention remuneration policies had in the pre-amendment period.

The *Patent Law* defines an "employee invention" as an invention that falls within the scope of the employer's business that was developed through an employee's actions performed to fulfill a duty to the employer. The rights and liabilities arising from employee inventions are governed by Section 35 of the *Patent Law*. Section 35 assigns the right to an employee invention to the employee, but stipulates that: (1) the employer shall receive a non-exclusive license (i.e., the shop right) without paying compensation (as in the U.S.); and (2) an employee who vests the right to obtain a patent or the patent right in the employer shall have the right to receive a reasonable remuneration (as in Germany) in accordance with any agreement, employment regulation or any other stipulation. Before 2005, Section 35 further provided that the amount of such remuneration should be decided by reference to the "amount of profits made by the employer from the invention" and "the contribution made by the inventor." However, unlike German patent law, there has been no clear standard for calculating "reasonable remuneration" in Japan. This ambiguity caused many firms to assume for a long time that whatever amount of compensation they awarded in accordance with their policies should be regarded as "reasonable" regardless of whether the inventor-employees agreed with it or

not.

Although there are a variety of compensation plans implemented by Japanese firms, a typical plan consists of two parts: (1) fixed, nominal payment at the time of filing a patent application or patent registration, and (2) contingent, revenue-based payment when inventions actually generate value, e.g., realized sales, profits, or royalty income. The latter may be a percentage of sales revenue or a fixed amount of money paid out when a performance measure achieved a certain milestone. Some plans have upper limits to payouts per year or per patent.

Until recently, many Japanese firms would pay inventors only a nominal amount of compensation at the time of patent filing or registration (i.e., only part (1) of the above typical plan). For instance, in the questionnaire survey conducted by the Japan Institute of Invention and Innovation in 1986, which covers 300 companies chosen at random from among the top 800 companies in terms of the number of patent applications filed, 93.3% of firms had implemented compensation plans based on filing or registration, whereas only 60.1% had compensation plans based on revenue from patents. The data indicate that even among companies that actively filed patent applications, one-third paid only a nominal amount of compensation.

Furthermore, most Japanese firms did not allocate sufficient resources to ensure that their employees understood their remuneration policies. According to the firm survey conducted by the Institute of Intellectual Property in 2002, only 17% of Intellectual Property (IP) managers believed that their employees “largely understand their invention remuneration policy” or “know what types

of remuneration exist in their firm” (JPO 2003). The rest believe that their employees are not well informed regarding their remuneration policy (see Table 1). At the same time, in answering the question “What is the purpose of revenue-based remuneration for employee inventions,” nearly 90% of the same IP managers chose “in order to encourage employee inventions” as the second most important reason after “because Section 35 of the *Patent Law* requires it.” If remuneration plans are implemented as incentive schemes, why don’t firms try harder to familiarize their employees with these plans?

Despite their claims, it seems clear to us that the employers had a tendency to play down the incentive effects of their invention remuneration policies until recently. They had created such policies primarily to comply with Section 35. This widespread passivity may indicate either that firms believed their remuneration policies did not have much incentive effect (possibly due to small payouts and long time lags between filings and payouts) or that they were concerned about some of the downsides to invention remuneration. That such ambivalence could be observed in most Japanese firms’ treatment of invention remuneration raises doubts about whether monetary compensation for employee inventions has had any impact on inventive effort or productivity. The changes in the *Patent Law* should also be evaluated in this context.

The rest of the paper is organized as follows: section 2 presents the history of the legal treatment of employee inventions. Section 3 discusses possible downsides to remuneration policies for employee inventions. Section 4 presents the research questions we investigate in this paper and

section 5 explains the datasets we use in our analyses. Section 6 presents our estimation results and section 7 summarizes our findings.

## **1 Historical Development of Japanese Patent Law**

### **1.1 Employee Inventions**

The Japanese patent system was established in 1885 when the government issued an ordinance on exclusive licenses and established the Patent Office.<sup>1</sup> Legal provisions for employee inventions first appeared in the 1909 amendment to the *Patent Law* which stipulated that the patent right to employee inventions basically belonged to their employers. The 1921 amendment (Section 14) reversed the assignment of rights, stating that employee inventions basically belonged to the inventors while firms should have non-exclusive rights to use their employees' inventions. The revised law further required that, in order to obtain the exclusive right to use these inventions, a firm must pay a "reasonable remuneration" to the inventors who transferred their patent rights to their employers. This provision was converted into Section 35 without substantial modification at the time of the revision of the *Patent Law* in 1959 and remained in place until 2005.

### **1.2 The Limited Role of Section 35**

Despite the legal requirement to compensate employees for their inventions, a survey of the

---

<sup>1</sup> Japanese government initially enacted *Provisional Regulations for Exclusive Licenses*, its first patent law, in 1871. However, the enforcement of this law was suspended the following year primarily because of the lack of administrative capacity including a shortage of patent examiners.

member firms of the Enterprises' Industrial Property Rights Association (currently the Intellectual Property Rights Association) conducted by the Japan Patent Office in 1956 revealed that roughly one-third of respondents did not have any provisions for invention remuneration, indicating that a substantial number of actively patenting firms did not have any formal compensation plans for employee inventions. Section 35 did not specifically require firms to have formal provisions for remuneration, and it is hard to imagine that inventor-employees could demand more compensation for their inventions without risk to their careers. We assume that inventor-employees did not receive any cash remuneration in firms where such plans were not formally offered even after the 1959 revision of the *Patent Law*.

Although a gradually increasing number of firms implemented remuneration policies in the next few decades, the amount paid to inventors continued to be small. As we noted earlier, the survey conducted by the Japan Institute of Invention and Innovation in 1986 shows that the 93.3% of the three hundred actively patenting firms surveyed had instituted invention remuneration at the time of patent filing or registration, whereas only 60.1% had compensation plans based on patent revenues from sales or royalties. This indicates that one-third of companies that actively filed patent applications were paying only a nominal amount of compensation in the mid-1980s. For decades, business leaders believed that their firms would be judged to be paying “reasonable” remuneration and fully complying with the *Patent Law* if they had implemented formal provisions for invention remuneration, regardless of the amount to be paid, because employees had implicitly accepted the



provisions by agreeing to work for the firm.

It was only in the late 1990s that Japanese firms started beefing up their remuneration provisions in response to: (1) the increasing perception that utilizing and defending its own intellectual property rights could reinforce a firm's competitive advantage; (2) the 1998 Amendment to the *Patent Law* that raised the value of patents by shortening the time it took to receive a patent and by making it easier to obtain relief for patent infringement; and (3) several lawsuits over remuneration for inventions that were filed in the late 1990s, foreshadowing more conflicts between employee-inventors and employers in the following decade. According to a survey of 347 manufacturing firms listed on the Tokyo, Osaka, and Nagoya stock exchanges conducted by Onishi (2010), the number of firms with revenue-based compensation increased from 199 (57.3%) in 1995 to 299 (86.2%) in 2005 (see Figure 1).

### **1.3 Increase in Legal Battles between Employers and Employees**

The trend of increasing remuneration for inventions accelerated after the defendant firm lost in the *Olympus* case,<sup>2</sup> in which an inventor demanded additional compensation despite the fact that his employer had already paid him in accordance with its remuneration policy. The Tokyo High Court (2001) and the Supreme Court (2003) held that the compensation plan that Olympus had unilaterally determined did not provide "reasonable remuneration" and was therefore invalid. The courts also held that, irrespective of the existence of a compensation plan, the final authority to decide the

---

<sup>2</sup> This case was filed at the Tokyo District Court in 1995 and the first judgment was delivered in 1999.

appropriate amount of remuneration was vested in the courts.

The Supreme Court ruling in this case encouraged many other inventors to file suits seeking additional compensation for their inventions. Figure 2 shows the rise in the number of lawsuits filed by employee-inventors in district courts from 1990 through 2007 that had been decided as of November 2008. There is an obvious increase after 2001 despite the truncation problem. Furthermore, in these cases the courts tended to order employers to pay large amounts of compensation.<sup>3</sup> In this new legal environment, Japanese firms that had not adopted any revenue-based remuneration policies for employee inventions hurried to implement such plans.

#### **1.4 Amendment to Section 35**

The increase in lawsuits caused anxiety among Japanese firms because it increased the risks associated with R&D investment. Business leaders and policymakers agreed that litigation might negatively affect the businesses' use of the patent system and their competitiveness in the global market. As a result, Section 35 was amended in 2004. Article 4 of the revised Section 35 provides that the payment of compensation in accordance with the predetermined remuneration plans would be deemed "reasonable" if: (1) a negotiation between the employer and the employee takes place in order to set standards for determining the award amount; (2) these standards are disclosed; and (3)

---

<sup>3</sup> *Nichia Corporation* is the most famous of these cases. In 2004 a district court ordered Nichia Corporation to pay twenty billion yen to the inventor of a blue light-emitting-diode (LED). The firm and the inventor, Shuji Nakamura, eventually agreed on the payment of ¥840 million under a settlement coordinated by the Tokyo High Court. The amount is still the largest ever made to an employee of a company as compensation for an invention in Japan.

the employees are consulted on the calculation of the amount of the award.

This revision was intended to require the court to place more weight on procedural rationality rather than on the fairness of the amount of compensation. It is expected that once a court determines that a compensation plan was adopted through procedures that can be considered reasonable, the court cannot question the adequacy of the amount paid to the inventor unless circumstances change drastically or the invention in question generates profits much greater than what was expected.

Article 5 of Section 5 was also revised to require courts to balance an inventor's claim against the firm's contributions to the invention. When a firm lacks a specific provision to determine the level of payment, the amount of the compensation shall be determined by taking into consideration: (1) the amount of profit to be received by the employer from the invention; (2) the employer's costs and contribution to the invention's development; (3) treatment of the employee; and (4) any other circumstances relating to the invention.

## **2 Discussion: Concerns About Invention Remuneration**

Before discussing the implications of the patent law changes for inventor behavior and productivity, we summarize the explanations for why many Japanese firms had been indifferent toward making employees aware of their remuneration plans. Note that, if firms had been reluctant to promote remuneration policies as a means to motivate employees for good reasons, the new legal requirement for disclosure and consultation could also have a downside.

First, one possible concern is equitable treatment of other employees. Many large firms are diversified and the revenue shares of divisions vary. If remuneration is proportional to the revenue an invention generates, the researchers in large divisions would have an advantage. Furthermore, patenting inventions may be easier in some technological fields than in others, which could also lead to differences in remuneration. If gaps in remuneration payouts across divisions become substantial, those in disadvantaged divisions may become demoralized. Another consideration is the relationship between revenue and non-R&D departments. Successful commercialization often requires coordinated efforts across research, development, marketing, manufacturing, and sales departments. If the revenue generated is the result of this cooperation among departments, why would the firm only reward those in the research group? Maintaining equitable treatment may be desirable to encourage cross-functional cooperation and partnership.

Second, management might be concerned about the problem that economists call the “multitasking agency problem” (Holmstrom and Milgrom 1991). Note that researchers might have important tasks other than invention such as safety testing, producing technical material for sales people and customers, briefing senior management, training new employees, etc. There are also important research activities that do not directly lead to patents or more revenue such as developing technical capabilities that will be valuable in the long run. Offering compensation schemes that depend only on the filing or registration of patents or the revenue generated may cause employees to distort their allocation of time, attention and energy away from the optimal allocation for the

employer. For example, researchers may prefer not to involve new employees who need training because having more participants may dilute their share of remuneration if a project succeeds. Involving less experienced employees, however, may be indispensable to developing new talent and passing technical know-how to the next generation of researchers.

Third, as Owan and Nagaoka (2010) discuss, extrinsic rewards such as remuneration may crowd out intrinsic motivation. This problem could be modeled as one similar to the multitasking agency problem. When presented with a compensation scheme that depends only on the success of the projects (i.e., patents and revenue), risk-averse agents may shift towards safer projects that are more likely to generate some patentable technology or focus more on incremental technological developments that are likely to be used in existing products. Such distortions are especially costly when researchers are already motivated intrinsically and pursuing risky, but potentially highly profitable, exploratory projects.

If these concerns are real, management will face trade-offs. On one hand, insufficient remuneration reduces the incentive effect while raising the legal risk. On the other hand, paying generous remuneration might cause the abovementioned equity and distortion problems. The Institute of Intellectual Property survey offers some insights into firms' expectations. Figure 3 shows the responses to the question, "What impacts do you expect when the amount of remuneration drastically increases?" It is clear from the survey results that many IP managers are concerned about greater inequity between researchers and non-R&D employees while some others also express

concern about distracting highly motivated researchers, which is consistent with our earlier discussion.

### **3 Research Questions**

In order to have an informed discussion about the issues discussed above, we need to study the relationship between remuneration policies, actual and perceived, and the R&D performance of inventors. Mapping this relationship is a very challenging task because the policies are never randomly assigned and there are many factors that could influence a firm's decision to introduce or modify its remuneration practices. These confounding factors lead to estimation bias, the direction of which may not be obvious. In addition, there are a variety of remuneration policies and the impact of a policy should depend on its actual structure. Another complication is heterogeneity in how firms communicate their policies to their employees. Some firms may adopt a remuneration policy to comply with the letter of *Patent Law* but fail to allocate any managerial resources to informing their employees of the change.

In the rest of this paper, we will address the following questions:

- How well informed were inventor-employees of their firms' invention remuneration plans before the 2004 amendment to the *Patent Law*?
- How is the incidence of a certain type of remuneration policy or the accuracy of employees' perceptions of their firms' policies associated with industry, firm, and employee

characteristics?

- What effects do different types of remuneration policies have on R&D performance?

The answers to the second question can be used to estimate the treatment effect examined in the third question. As noted above, simple regressions without randomized treatment typically lead to significant selection bias. If firms with certain characteristics tend to perform better and, at the same time, are more likely to adopt revenue-based remuneration policies, the correlation between the performance and the remuneration policies may be significantly positive even if the true causal effect is negligible. The actual sign of the bias, however, is not known *a priori*.

While a number of studies have looked at the impact of monetary compensation on the inventive productivity of R&D researchers (see, for example, Honig-Haftel and Martin (1993) and Zenger and Lazzarini (2004)), the mechanism through which a pay scheme affects the inventive process has not been adequately scrutinized. In the case of the US market, generous invention remuneration may be necessary to retain star researchers, thus market pressure may force a firm to adopt a certain type of compensation for valuable inventions. This pressure is less pronounced in Japan where the turnover rates of scientists and engineers are still low in a majority of industries. Owan and Nagaoka (2010) analyze how intrinsic and extrinsic motives including monetary incentives affect inventive productivity and find that intrinsic motives are far more important in explaining research output and quality. Onishi (2010) empirically analyzes the relationship between compensation policy type and research output at the firm level and finds that the introduction of revenue-based compensation

policies did not enhance firms' patent outputs. However, these studies do not explain why the new compensation policies did not affect inventors' motivation. We attempt to fill that gap in this paper.

## 4 Data

### 4.1 Sources of data

We combine two sources of data to examine our research questions. First, we employ inventor-level, patent-level, and project-level information from a survey of 5,091 Japanese inventors on 5,278 patents conducted by the Research Institute of Economy, Trade and Industry in 2007 (hereafter the **RIETI inventor survey**).<sup>4</sup> Roughly 70% of the observations come from a stratified random sampling of triadic patents--patents submitted simultaneously to patent offices in Japan, the US and Europe--while roughly 30% of the observations are a random sample of non-triadic patents. In addition to its richly detailed information on inventor, patent and project characteristics, the RIETI inventor survey makes available three measures of inventor productivity: (1) *npat*, the number of domestic patents the project produced or is expected to produce (a 6-point categorical variable); (2) *pat\_val*, the economic value of the surveyed patent evaluated on a relative basis by the inventors themselves (a 4-point categorical variable); and (3) *use*, the incidence of commercial use of the patented technology including licensing and startups.

Other survey findings that we use to control for heterogeneity in inventor, patent and project

---

<sup>4</sup> For more detailed description of the RIETI inventor survey, see Nagaoka and Tsukada (2007) and Nagaoka and Walsh (2009).



characteristics include gender, age, education background, and R&D affiliation of respondent-inventors, the number of inventors for the focal patent, the purpose, nature and stage of the project generating the patented technology, and the man-months allocated to the project (see Table 3). Additional unique pieces of information we include as control variables are subjective evaluations of sources of motivation.<sup>5</sup> These motivation variables are included because they are likely to be correlated with personal attributes and corporate culture, which in turn may be associated with firms' decisions on remuneration policies.

The second source of information is the firm-level survey on remuneration policies conducted by Koichiro Onishi, which was sponsored by the Institute of Intellectual Property in 2005 (hereafter the **IIP firm survey**).<sup>6</sup> The survey targeted 836 manufacturing firms listed on the first section of the Tokyo Stock Exchange as of March 31, 2005. Among the targeted firms, 360 firms responded to the questionnaire, a response rate of 43.1%. We use the data for 347 firms after excluding two firms that had not obtained any patents in the preceding 15 years and 11 firms that refused to answer some major questions. These data have two advantages. First, they provide a wealth of information on the remuneration policies of large Japanese firms including remuneration types (e.g.,

---

<sup>5</sup> These variables are the responses to the following question: “How important were each of the following factors as a source of motivation for your invention? (1) satisfaction from contributing to the progress of science and technology (*mtvn\_sci*), (2) satisfaction from solving challenging technical problems (*mtvn\_chall*), (3) enhancing your organization's performance (*mtvn\_org*), (4) career advancement and better job opportunities (*mtvn\_career*), (5) reputation and prestige (*mtvn\_rep*), (6) improved research conditions such as higher budgets (*mtvn\_budget*), and (7) monetary rewards (*mtvn\_money*). A 5-point Likert scale is used to answer each question (1=absolutely unimportant, 5=very important).

<sup>6</sup> For more detailed description of IIP firm survey, see Onishi (2006, 2010).

filing/registration-based vs. revenue-based).<sup>7</sup> Second, the IIP questionnaire asks each firm about the details of its remuneration policies in 1990 and whatever changes that were made between 1990 and 2005, when the survey took place. These details enable us to construct panel data on the evolution of remuneration policies for 347 major Japanese firms.

We also used three additional sources of data. We supplemented the firm characteristics data by matching them with the results of the Ministry of Economy, Trade and Industry's annual *Basic Survey of Japanese Business Structure and Activities*. We also collected inventor-level accounts of their firms' remuneration policies from the follow-up survey conducted by RIETI in the summer of 2008 of those respondents to the RIETI inventor survey who provided their email addresses (hereafter RIETI II). The IIP firm survey provides firm-level panel data on remuneration policies for employee inventions from 1990 through 2005 while RIETI II offers the inventors' accounts of what remuneration policies they believed were in effect during the course of invention for the patents applied for from 1995 to 2002.<sup>8</sup>

As Table 2 shows, after matching the RIETI inventor survey with the IIP firm survey, our combined dataset has 2341 inventors working for 217 listed firms. The number of inventors working in the same firm ranges from 1 to 156 with a highly skewed distribution. The average is 10.8 inventors per firm. Since RIETI II covers only a portion of the original RIETI survey's inventors, matching it with

---

<sup>7</sup> Other information collected includes types of revenue measures (sales vs. licensing vs. transfer), types of patents the policy is based on (domestic vs. foreign), amount of payout limits, frequency of payouts, etc.

<sup>8</sup> If their remuneration policy changed during the research period, we asked inventors to identify the policy in effect during the time period when they made their most significant breakthroughs. We then selected the middle year of the period minus 1 year as the "matching" year for our comparison.

the IIP firm survey substantially reduces our sample size. The list of variables we use in our analyses is presented in Table 3.

#### **4.2 Conflicting accounts from employers and employees on their remuneration plans**

We first examine how well the two sources of information coincide with each other. The matching results are presented in Table 4. When we look at the rate of discrepancies at the firm level, all employees at more than 90% of firms reported correctly whether their firms offered fixed payouts at the time of filing applications or registration. This high rate of accuracy is understandable given that most large Japanese firms had such policies in place for many decades and most inventors who had patented their inventions had already received such payouts. When we asked about revenue-based remuneration determined either by sales or royalties, however, some employees answered that such a policy did not exist at nearly 60% of the firms that actually had one. When we looked at discrepancies between perceptions and reality at the industry level, we did not see much variation across industries; 40-70% of employee-inventors in each industry failed to correctly identify the remuneration policies they were subject to.

The firms surveyed should have little incentive to report untruthfully because the Institute of Intellectual Property, although funded by the government, is a think tank whose primary purpose is to conduct policy-oriented research on intellectual property and provide member firms with various IP databases. Given that the IIP does not have an enforcement or monitoring role, most of the discrepancies can be attributed to the inventors' ignorance of their firms' actual policies, although

some discrepancies may be the result of inaccurate recollection by IP managers.

There are a number of possible reasons why the accounts of employers and employees do not coincide. First, since a number of firms changed their remuneration policies at some point between 1990 and 2005, depending on when an inventor believes the critical stage of his or her work took place, the perceived remuneration policy may be different from the one the IP manager believes to have been in effect during the matching year. But the discrepancies are not reduced much by allowing a longer time lag or excluding the firms that revised their policies. Second, the description of an actual remuneration policy may cause some employees to incorrectly believe that the policy is not partly based on revenue. For example, some firms pay remuneration when an invention realizes actual sales or licensing but the award amount is fixed and does not depend on the amount of revenue. Since we have the detailed information on firms' remuneration policies, we can re-examine the data after excluding plans that may not be correctly perceived as revenue-based. Again, the discrepancy rate is not reduced much by the exclusion.

Although this finding of prevalent inconsistencies between the accounts of the employers and the employees is certainly puzzling and disturbing, it is somewhat consistent with the 2002 survey conducted by the Institute of Intellectual Property which we mentioned in the introduction. Our data confirmed the earlier finding that employees are not offered much chance to learn the details of their remuneration policies even if provisions for revenue-based remuneration exist.

Finally, note that almost all listed firms with substantial patent stock already had some

filing/registration-based fixed remuneration policy in effect for decades. Only 10 out of 217 firms did not have any type of filing or registration-based fixed remuneration policies at some point during the years from 1990 to 2005. Since the responses on fixed payments do not have sufficient variation to allow any meaningful quantitative analyses, we will focus on revenue-based remuneration in the next section.

## **5 Analysis**

### **5.1 What determines the incidence of revenue-based invention remuneration policies and their accurate identification by employees?**

Our first question is what types of firms are more likely to introduce revenue-based remuneration policies. The first two columns in Table 5 present random-effect probit estimation results for the firm-reported incidence of revenue-based remuneration using firm-year panel data from the IIP firm survey. We find that revenue-based remuneration policies are more common in larger firms with greater patent stock in the industries with the most lawsuits related to invention remuneration. The positive association between performance-based pay policy and patent stock may imply that providing researchers with monetary incentives is more important in such firms or that the risk of inventor lawsuits is greater in technology-oriented firms. The positive correlation between the incidence of revenue-based remuneration and the accumulated number of lawsuits in the same industry suggests that firms in an industry where lawsuits related to invention remuneration have

been filed may be more alert to the legal risk and thus more likely to have revenue-based remuneration.

As we have argued earlier, employees may not be motivated by the existence of revenue-based remuneration if they are not fully informed about the policy. We investigate whether the firm-reported or employee-reported incidence of remuneration policies affects the performance of R&D researchers. An employee's recollection of the remuneration policy in place at the time of the invention should reflect the actual policy, the amount of resources their firm spent familiarizing their employees with the policy, and the employee's interests in monetary rewards. Therefore, the perceived policy should depend on inventor characteristics as well as firm characteristics. This hypothesis is supported by the evidence.

Columns 3 and 4 in Table 5 show that an employee's identification of the employer's revenue-based remuneration policy does depend on some of the inventor's characteristics as well as the firm size. Since there is a prevalent tendency of "under-identification," the results also illustrate who is more likely to know their remuneration policy accurately. Younger inventors who are motivated to improve organizational performance and secure better research conditions are less likely to know of the existence of a revenue-based remuneration policy although this tendency may also be a product of the firm's practices. There are two major differences between the firm-reported and the employee-reported policy variables. First, the accuracy of employees' perceptions is not correlated with the number of patent lawsuits in an industry, implying that increasing numbers of

lawsuits may induce the firms to take defensive measures, i.e., adopt revenue-based remuneration, but without drawing their employees' attention to their new "opportunities" to earn more money. Secondly, perceived policy accuracy is not correlated with patent stock value, implying that technology-oriented firms are more likely to adopt revenue-based remuneration but do not necessarily publicize it much, perhaps out of fear that monetary incentives may have negative repercussions. Another interpretation might be that technology-oriented firms attract intrinsically motivated people who do not pay much attention to what remuneration policy the employer has. However, this explanation is inconsistent with another finding, shown in Table 5, that the importance of an inventor's interest in science as a source of motivation is not significantly correlated with their policy perceptions. The coefficient for the last motivational factor, *mtvn\_money*, is not significant either. This result is somewhat puzzling because people should be more likely to regard money as a source of motivation in firms with revenue-based compensation policies.

## **5.2 How are R&D performance measures associated with firm-reported and employee-reported remuneration policy measures?**

Since we have constructed three measures of inventive performance based on the RIETI inventor survey, it is natural to ask how the adoption of performance-based pay policy is associated with the inventive performance of employees. We ran ordered probit regression for the number of patents generated from the project (*npat*), the value of the patents (*pat\_val*), and probit regression for commercialization (*use*). We also constructed binary variables of the above quantity and quality

measures (npat2 and pat\_val2: see Table 3 for definitions) for the purpose of comparing the results with those of the propensity score matching method discussed below.

Tables 6 and 7 show the results for firm-reported and employee-reported incidence of filing/registration-based and revenue-based remuneration policies, respectively. The results show that neither the actual nor the perceived incidence of filing/registration-based invention remuneration is correlated with any of the performance measures, supporting our view that almost all large firms with substantial patent stock have had such policies for decades. There is also little variation in adoption once we control for the size of firms and their patent stock. We therefore focus on revenue-based remuneration.

Table 6 shows that firms with a revenue-based remuneration policy are likely to produce more valuable patents but not necessarily more patents (at least in the ordered probit model that uses more information than the compressed binary variable in the probit model), or to commercialize inventions more frequently. The naïve interpretation of this result is that performance-based pay encourages inventors to tackle more challenging but potentially profitable technical problems thus leading to valuable patents. Another interpretation, however, is that the firms that have valuable R&D investment opportunities are more likely to adopt revenue-based remuneration to speed up the inventive process or reduce the risk of being sued, thus offering more rewards to productive inventors.

The relationship between remuneration policy perceptions and performance measures shown in



Table 7 gives us a slightly different picture. Inventors who believe they work under revenue-based remuneration policies are more likely to commercialize patented technology. Again, this might suggest that awareness of revenue-based remuneration policies encourages inventors to produce valuable patents and to put forth more effort to commercialize their inventions. However, such causality is not so easily justified because there are many confounding factors that could impose bias on the estimated coefficients.

First of all, firms whose competitive advantage hinges on intellectual property and technical know-how may introduce more substantive revenue-based remuneration policies and allocate more managerial resources to familiarize their employees with these policies, resulting in greater employee recognition in firms with more valuable patents and a higher incidence of commercialization. Second, the inventors who generate more valuable patents and successful commercialization may devote more attention and time to understanding the remuneration policy adopted by their employers. In order to mitigate the selection bias caused by heterogeneity among treated and controlled subjects, in the following sections we attempt to estimate more accurate measure of impacts of the actual and perceived remuneration policies using the propensity score matching (PSM) method.

### **5.3 Impact of revenue-based remuneration: propensity score matching method**

Probit modeling puts more weight on the firms or the employees of firms where the introduction of revenue-based remuneration is less warranted than those where revenue-based remuneration is taken for granted (i.e., the likelihood of the former having such a policy is around 50% vs. very high

for the latter) like the ordinary least squared estimation model. One way to better estimate the causal impact of such a policy is to compare the impact of the treatment between firms that are as similar as possible. The propensity score matching model allows us to measure the difference in performance between firms that have the same propensity score with and without revenue-based remuneration.

Table 8 compares the predicted probability increase of having revenue-based remuneration using the results from the PSM method and the original probit estimation, respectively. There are two notable differences. First, the effect of the firm-reported incidence of revenue-based remuneration on the value of patents is reduced and becomes less significant in the PSM than in the ordinary probit. Second, the impact of the perceived policy on commercialization becomes more salient and significant. This suggests that perceived revenue-based remuneration encourages employees to invent more technology with commercial applications. The PSM method, however, eliminates only a certain type of selection bias and cannot correct for biases caused by unobservable characteristics that affect both the choice of remuneration policy and R&D performance. Therefore, it is still possible that the inventors who expect their inventions to be commercially expend more effort to find out their firms' remuneration policy.

#### **5.4 Impact of revenue-based remuneration: probit model with instrument variables**

To cope with this endogeneity, we attempt to estimate previous probit models with the instrumental method, using “recognition rate” as an instrumental variable. The recognition rate is the share of colleagues in the same firm who correctly reported they had a revenue-based remuneration

policy.<sup>9</sup> This recognition rate should reflect the firm's actual policy and its allocation of resources to familiarize its employees with the policy. Therefore, the recognition rate should be correlated with an employee's perceived remuneration policy but is likely to be orthogonal to the error term in the probit model we estimate because the colleagues' recognition of the firm's policy is less likely to be affected by the employee's research performance. In the results of the regression of perceived policy on instrumental variables, this variable is a highly significant but somewhat low R-square 0.25.

Table 9 shows the results of the probit estimation with instrumental variables and indicates that the coefficient for the perceived remuneration policy variable is not significant for all research output variables. Most notably, its positive impact on commercialization disappeared, implying that the observed correlation between the perceived policy and the invention's commercialization is not causal but rather is the result of heightened awareness of potential remuneration payouts after commercialization.

Why do monetary incentives completely fail to induce additional innovation outputs? One explanation is that inventors are mostly motivated by intrinsic benefits rather than extrinsic rewards as suggested by Owan and Nagaoka (2010). In order to examine whether this explanation is consistent with the data, we finally estimate the same models as estimated above with a sub-sample composed of the inventors who do not view monetary rewards as unimportant (i.e., those who rated "the importance of monetary rewards as a source of motivation for doing the research project" 3 or

---

<sup>9</sup> To use this variable effectively, our sample is limited to firms with more than two respondents.

higher in the 5-point Likert scale in the Inventor Survey). These inventors are more likely to react to a revenue-based remuneration policy than others.

Table 10 shows the estimation results for probit and IV probit model with this sub-sample. In the IV probit model, the coefficient for perceived remuneration policy is marginally significant for increasing commercialization of their patents. However the same coefficient is significantly negative for the value of the patent. These results are consistent with the argument in Owan and Nagaoka (2010) that monetary incentives may induce an inventor to select a safe and easily commercialized research project rather than a more challenging but potentially more valuable project, and therefore could cause a deviation from the most efficient outcome. The results are consistent with the view that monetary incentives affect only those who do not see monetary rewards as an unimportant source of motivation, but the effect could be counterproductive if the distortion in project selection is significant.

## **6 Conclusion**

In this study, we summarize the historical development of the legal treatment of invention remuneration policies and examine the impact of such policies on R&D performance based primarily on the 2005 IIP Invention Remuneration Survey, the 2007 RIETI Inventor Survey, and its 2008 follow-up survey. Tracing the linkage between firm policy and performance is complicated by Japanese firms' unwillingness to publicize the details of their policies to their employees before the

2004 amendment of Japan's patent law. Our analysis shows that the firm-reported incidence of revenue-based remuneration is positively associated with the value of patents while the employee-reported incidence of revenue-based remuneration is positively associated with commercialization, although both coefficients are only marginally significant. Our analysis based on the propensity score matching (PSM) method shows that the firm-reported policy variable's association with the value of patents disappeared once more accurate measures of the treatment effects are computed. On the other hand, the employee-reported perceived revenue-based remuneration remains positively associated with commercialization with greater significance implying that monetary incentives may be encouraging the inventors to put forth more effort to apply their patented technology to commercial use. The PSM method, however, does not allow us to rule out the possibility of reversed causality, namely that inventors who expect their inventions to be commercially used expend more effort to find out their remuneration policy. To correct for such bias, we have employed instrumental variable estimation and demonstrated that the employee-reported measure of perceived revenue-based remuneration had little impact on any of the inventive performance measures.

Lastly, our estimates indicate that perceived revenue-based remuneration is significantly positive for commercialization but negative for valuable patents among the inventors who do not see monetary rewards as unimportant after controlling for selection bias. Namely, revenue-based remuneration encourages inventors who appreciate monetary rewards to make additional

commercializable inventions, but it may shift their attention from high risk, high return projects to work on more incremental and easily commercialized ones. These results indicate that using monetary compensation for R&D activities could have limited or counterproductive impacts on R&D productivity, and policy makers and managers should therefore exercise caution in promoting monetary compensation for inventors.

From this perspective, it is very important to monitor developments after the 2004 amendment to the *Patent Law*, which caused many Japanese firms to change their ways of determining and implementing their remuneration policies for employee inventions. It certainly granted more bargaining power to employees in R&D divisions and requires more effort by firms to justify their pay policies. Table 11 shows how the actual payment of remuneration for employee inventions changed after the 2004 amendment . The average payout among 700 actively patenting firms increased from ¥7.4 million per firm in 2003 to ¥11.7 million per firm in 2007. This 59 percent increase in rewards for inventors within a few years and expectations of further increases in the future could have a significant impact on their behavior. More importantly, firms now believe they are legally required to explain to their employees how their invention remuneration policies are designed. Inventors can see how much monetary reward they could receive through successful R&D efforts and will not see the remuneration payouts as windfalls any more.

What will be the overall impact of the increase in remuneration for employee inventions? There are two plausible arguments. First, invention remuneration policies will now be designed more as

incentive schemes rather than as measures taken to comply with the *Patent Law*. Employee involvement in designing compensation formulas might also help to enhance the effectiveness of the schemes. In the long run, it is also possible that the increased compensation will help to attract talented young researchers into industries. If such predictions are borne out, there will be a positive impact on the R&D productivity of Japanese firms.

The second possibility is that, if using monetary compensations for R&D activities could have counterproductive impacts on R&D productivity (*e.g.*, cause distortion in project selection as our last empirical analysis suggests) and low-powered incentives for inventors are rather optimal, the legally enforced introduction of new remuneration policies will simply harm R&D productivity and firm profitability. This potential downside of the policy change could be a substantial blow, especially for small and medium-sized firms where the issue of equity and the multitasking agency problem could be significant. It will take several more years to see the first reliable evaluations of the overall impact of the changes to the *Patent Law* and firms' practices on inventive efforts and R&D productivity given the time lags in every step of causal relationships between the changes in the law and R&D outcomes.

## References

Holmstrom, Bengt. and Milgrom, Paul. "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership and Job Design," *Journal of Law, Economics and Organization* 7 1991, special issue, pp. 24-52.

Honig-Haftel, S. and Martin, L.R. "The Effectiveness of Reward Systems on Innovative Output: An Empirical Analysis." *Small Business Economics*, Vol. 5 1993, pp. 261-269.

Japan Patent Office, *Research and Study on Institutionalized System for Employee Inventions*, 2003.

Nagaoka, Sadao, and Tsukada, Naotoshi. "Innovation Process in Japan: Findings from the RIETI Inventors Survey (in Japanese)," *RIETI Discussion Paper* 07-J-046.

Nagaoka, Sadao, and Walsh, John P. "The R&D Process in the U.S. and Japan: Major findings from the RIETI-Georgia Tech inventor survey," *RIETI Discussion Paper* 09-E-010.

Onishi, Koichiro 2006. "Do Compensation Systems for Employee Inventions Increase Incentives for Researchers? Evidence from Japanese Panel Data," (unpublished) included in the special report submitted to Japan Patent Office, Institute of Intellectual Property, 2006.

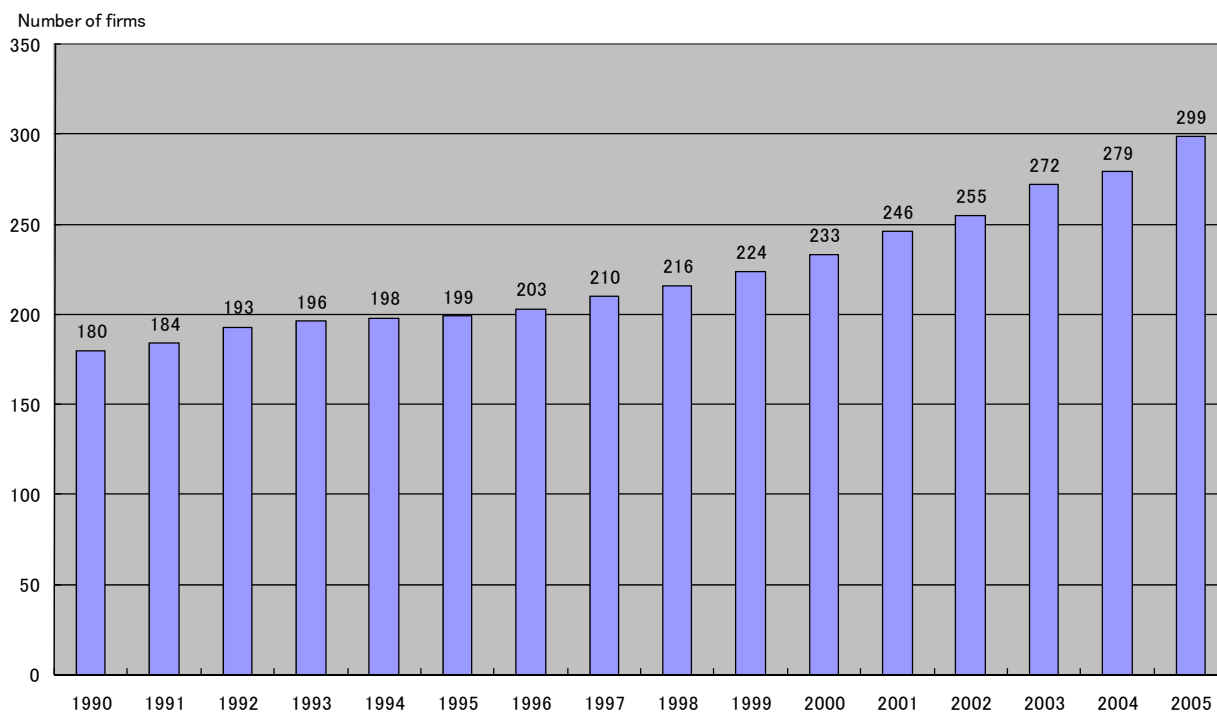
Onishi, Koichiro. "The Productivity Effects of Compensation Plans for Employee Inventions: New Evidence from Japanese Panel Data," mimeo, 2010.

Owan, Hideo and Nagaoka, Sadao. "Intrinsic and Extrinsic Motivation for Inventors," mimeo, 2010.

Zenger, Todd. R. and Lazzarini, Sergio.G. "Compensating for Innovation: Do Small Firms Offer High-powered Incentives That Lure Talent and Motivate Effort?" *Managerial Decision Economics* 25 2004, pp. 329-345.

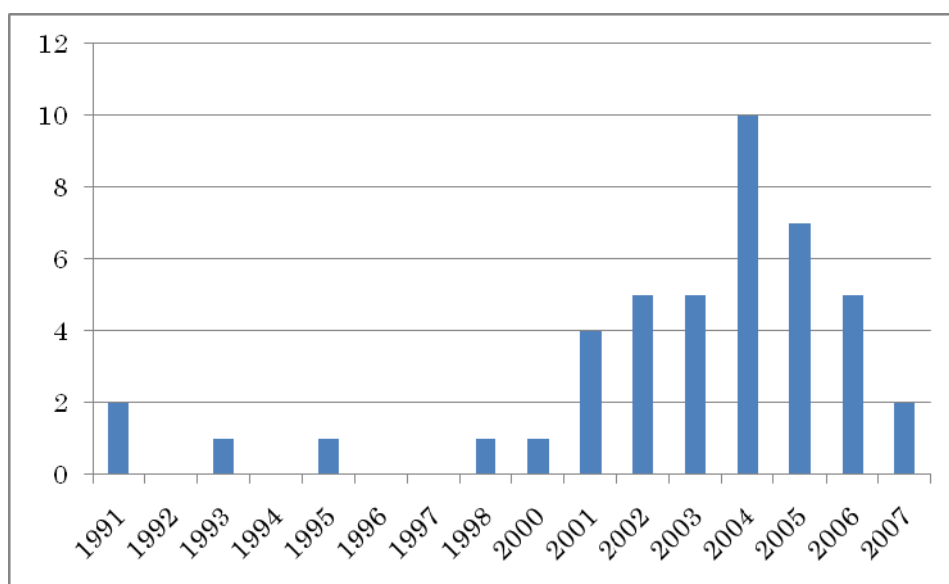


Figure 1 Number of firms with revenue-based remuneration policies



Data source: Onishi (2010).

Figure 2 Number of Patent Lawsuits Filed by Employee-Inventors



Note: Includes only lawsuits that had been ruled on by November 2008.

Source: IP lawsuit database in JIII.

Table 1 Employees' Knowledge of Their Firm's Inventor Remuneration Policy

Answers	Share
A majority know our inventor remuneration system to a large extent	10.2%
A majority know the main items of our inventor remuneration system	6.3%
A majority know that we have an inventor remuneration system and that its details are available for reading	63.1%
A majority know that we have an inventor remuneration system	12.9%
More than a half do not know whether we have an inventor remuneration system	6.6%
Our firm does not have provisions for inventor remuneration	0.6%
No response	0.3%

Note: These are the responses to the question "How much do your employees know about your firm's policy of remuneration for employee inventions to the best of your knowledge?"

Source: IPO (2003)

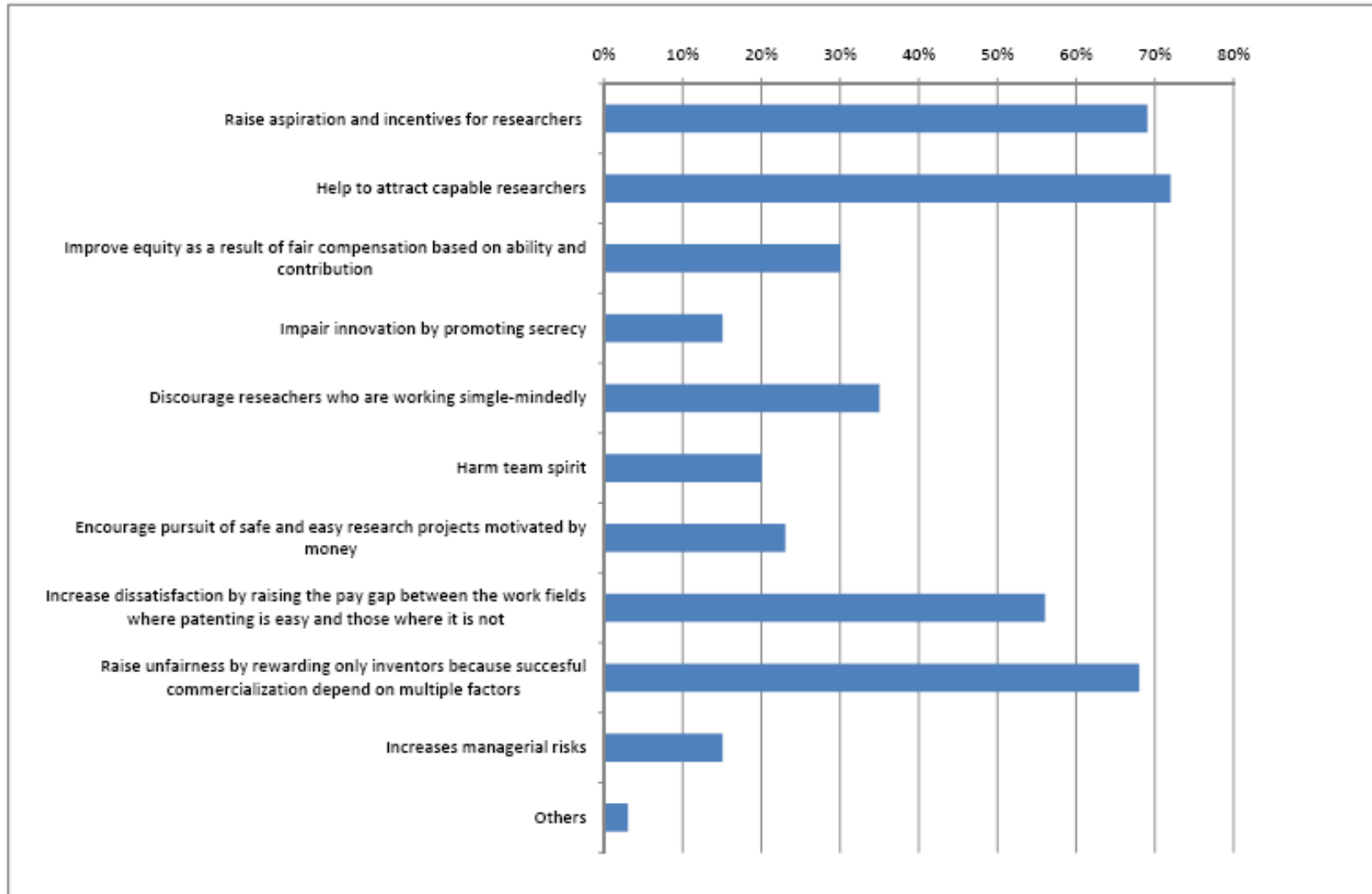
Table 2 Sample size after matching

	RIETI Inventor Survey	With firm characteristics	+ With IIP firm survey	+ With RIETI II
<b>Number of inventors</b>	5278	4856	2341	584
<b>Number of firms</b>		1326	217	142
Number of inventors per firm				
<b>Mean</b>		3.66	10.79	4.11
<b>Min</b>		1	1	1
<b>Max</b>		156	156	45

Table 3 List of variables

Variable name	type	Definition
Dependent variables		
npat	category	Number of patents (expected to be) generated from the project surveyed: 1 for 1; 2 for 2 to 5; 3 for 6 to 10; 4 for 11 to 50; 5 for 51 to 100; 6 for 101 or more
npat2	binary	Number of patents (expected to be) generated from the project surveyed: 0 for 1 to 5; 1 for 6 or more
pat_val	category	Economic value of the surveyed patent evaluated on a relative basis by the inventors themselves: 1 for "below average"; 2 for "above average"; 3 for "top 25%"; 4 for "top 10%"
pat_val2	binary	Economic value of the surveyed patent evaluated on a relative basis by the inventors themselves: 1 for "above average"; 0 for others
use	binary	Commercial use of the patent: 1 for patented technology being used in the product development or production process by the employer, licensed to other firms, or used by spin-out employees; 0 otherwise
Endogenous variables		
fixed_rem	binary	Incidence of filing/registration-based remuneration policy
rev_rem	binary	Incidence of revenue-based remuneration policy
perc_fixed_rem	binary	Perceived case of filing/registration-based remuneration policy
perc_rev_rem	binary	Perceived case of revenue-based remuneration policy
Independent variables		
mtvn_sci	category	Importance of satisfaction from contributing to the progress of science and technology as a source of motivation for invention: 5-point scale
mtvn_chall	category	Importance of satisfaction from solving challenging technical problems as a source of motivation for invention: 5-point scale
mtvn_org	category	Importance of performance enhancement of employer-organization as a source of motivation for invention: 5-point scale
mtvn_career	category	Importance of career advances and better job opportunities as a source of motivation for invention: 5-point scale
mtvn_rep	category	Importance of reputation and prestige as a source of motivation for invention: 5-point scale
mtvn_budget	category	Importance of improved research conditions such as higher budgets as a source of motivation for invention: 5-point scale
mtvn_money	category	Importance of monetary rewards as a source of motivation for invention: 5-point scale
sex	binary	Gender of inventor: =1 if male.
lnage	discrete	Logarithm of inventor's age
rdd	binary	Indicator of the inventor's affiliation with an R&D division
lninventors	discrete	Logarithm of the number of inventors of the patent
lnmanmonth	discrete	Logarithm of man-months allocated to the project
seeds	binary	Indicator of a seeds-oriented research: answer to the question of whether the motivation of the research was to find commercial applications of scientific or technological discoveries
explore	binary	Indicator of an exploratory research: answer to the question of whether the motivation of the research was to explore for new technological seeds
basic	binary	Indicator of basic research
apply	binary	Indicator of applied research
dev	binary	Indicator of a development-stage research
purpose	category	Purpose of the research project: 1 for "to develop a new business", 2 for "to reinforce the existing business"; 3 for "to reinforce technical base or grow technical seeds"; 4 for other purposes
education	category	Educational background of the inventor: 1 for high school diploma; 2 for 2-year college or trade school diploma; 3 for college degree; 4 for master degree; 5 for Ph.D.
ayear	discrete	Application year dummies
myear	discrete	Middle of project period dummies
ind_code	category	Industry code (sector code set by the Securities Identification Code Committee)
ussub	category	Subcategory code in the US patent classification.
lnsale	continuous	Logarithm of firm sales
pat_stock	continuous	Patent stock computed assuming 15% depreciation rate
case_total	discrete	Accumulated number of IP lawsuits related to invention remuneration filed by employees in the same industry.

Figure 3 Firms' expectations regarding the impacts of drastically increasing the amount of remuneration



Source: IPO (2003)

Table 4 Discrepancies in firm and employee accounts of remuneration policy

**a. Does your firm have a filling/registration-based remuneration policy?**

		Inventor-employee		
		No	Yes	Total
Firm	No	1	2	3
	Yes	44	537	581
	Total	45	539	584

**b. Does your firm have a revenue-based remuneration policy?**

		Inventor-employee		
		No	Yes	Total
Firm	No	63	13	76
	Yes	206	302	508
	Total	269	315	584

Table 5 Determinants of firm and employee-reported incidence of revenue-based remuneration

Dependent variable	rev_rem		perc_rev_rem	
Unit of observations	Firm □ year		Inventor	
	(1)	(2)	(3)	(4)
fixed_rem	17.853 (2233.385)	20.500 (1909.723)		
lnsale	1.057 *** (0.179)	1.225 *** (0.247)	0.110 *** (0.037)	0.066 (0.042)
pat_stock	0.190 ** (0.088)	0.192 * (0.104)	-0.007 (0.018)	-0.009 (0.019)
case_total	1.153 *** (0.210)	-0.543 (0.675)	0.022 (0.040)	-0.261 (0.173)
mtvn_sci			0.044 (0.062)	0.040 (0.064)
mtvn_chall			0.025 (0.071)	0.016 (0.071)
mtvn_org			-0.091 * (0.054)	-0.072 (0.055)
mtvn_career			-0.010 (0.061)	0.013 (0.062)
mtvn_rep			0.044 (0.069)	0.035 (0.069)
mtvn_budget			-0.198 *** (0.061)	-0.189 *** (0.061)
mtvn_money			0.055 (0.057)	0.051 (0.056)
sex			0.416 (0.513)	0.323 (0.503)
lnage			0.644 ** (0.279)	0.657 ** (0.282)
education=2			0.255 (0.317)	0.258 (0.314)
education=3			0.185 (0.257)	0.127 (0.257)
education=4			0.266 (0.257)	0.290 (0.254)
education=5			0.108 (0.303)	0.183 (0.297)
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	No	Yes	No	Yes
Firm random effect	Yes	Yes	No	No
Observations	767	767	790	776
Log Likelihood	-152.09	-126.14	-507.32	-490.51

All independent variables in Table 3 are included in the estimation but omitted for perc\_rev\_rem. Standard errors are in the parentheses. Standard errors for perc\_rev\_rem are clustered by firms.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 6 Firm-reported incidence of revenue-based remuneration policy and R&D performance measures

	(1) order probit model		(3) npat2	(4) probit model		(5) use
	npat	pat_val		pat_val2		
fixed_rem	-0.125 (0.370)	-0.516 (0.326)	-0.01 (0.431)	-0.304 (0.436)	-0.341 (0.363)	
rev_rem	0.096 (0.082)	0.161* (0.084)	0.180* (0.099)	0.221** (0.090)	-0.056 (0.130)	
mtvn_sci	0.067** (0.029)	0.176*** (0.037)	0.045 (0.036)	0.166*** (0.043)	-0.051* (0.029)	
mtvn_chall	0.04 (0.039)	0.152*** (0.057)	-0.001 (0.048)	0.097* (0.055)	0.107*** (0.040)	
mtvn_org	0.012 (0.034)	0 (0.037)	-0.042 (0.040)	-0.01 (0.044)	-0.022 (0.034)	
mtvn_career	0.011 (0.030)	-0.025 (0.040)	0.014 (0.033)	0.002 (0.045)	0.009 (0.037)	
mtvn_rep	-0.017 (0.033)	0.072 (0.050)	-0.044 (0.036)	0.028 (0.060)	0.061* (0.034)	
mtvn_budget	0.066** (0.029)	-0.005 (0.031)	0.093** (0.038)	0.036 (0.035)	-0.093*** (0.035)	
mtvn_money	0.012 (0.030)	0.068* (0.037)	0.021 (0.031)	0.075 (0.048)	0.028 (0.032)	
sex	0.35 (0.237)	-0.089 (0.226)	0.687*** (0.253)	0.465 (0.377)	-0.112 (0.192)	
lnage	0.534*** (0.136)	0.333** (0.135)	0.431** (0.182)	0.466*** (0.180)	0.133 (0.191)	
education=2	0.229 (0.161)	0.105 (0.185)	-0.091 (0.213)	0.045 (0.263)	-0.117 (0.175)	
education=3	0.203* (0.118)	-0.087 (0.131)	0.04 (0.131)	-0.326* (0.184)	-0.159 (0.138)	
education=4	0.301** (0.126)	-0.044 (0.137)	0.174 (0.147)	-0.242 (0.195)	-0.221 (0.166)	
education=5	0.398*** (0.115)	0.186 (0.150)	0.305** (0.145)	-0.017 (0.224)	-0.215 (0.169)	
rdd	0.281*** (0.073)	-0.007 (0.092)	0.161* (0.091)	0.146 (0.097)	-0.223** (0.096)	
seeds	0.126* (0.065)	-0.041 (0.074)	0.122 (0.081)	-0.055 (0.097)	-0.113 (0.080)	
explore	0.262*** (0.087)	0.035 (0.104)	0.232** (0.096)	0.172 (0.143)	-0.302*** (0.102)	
basic	0.131 (0.083)	0.191** (0.078)	0.261*** (0.089)	0.183* (0.108)	-0.063 (0.082)	
apply	0.161*** (0.053)	0.194*** (0.058)	0.147** (0.072)	0.177** (0.074)	-0.098 (0.071)	
dev	0.127 (0.079)	0.157** (0.071)	0.067 (0.088)	0.066 (0.108)	0.275*** (0.063)	
lnsales	0.095*** (0.030)	-0.043* (0.025)	0.075** (0.034)	-0.03 (0.027)	-0.048* (0.027)	
pat_stock	-0.052** (0.023)	0.012 (0.021)	-0.064** (0.027)	0.019 (0.028)	0.04 (0.027)	
time dummy	yes	yes	yes	yes	yes	
US-subclass dummy	yes	yes	yes	yes	yes	
Observations	2010	1503	2008	1494	2003	
Log Likelihood	-2609.25	-1800.1	-1139.46	-805.44	-1244.39	

Some independent variables omitted from the table include lninventors, lnmanmonth, technical service dummy, and purpose of the project. Standard errors clustered by firms are in parentheses.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 7 Employee-reported incidence of revenue-based remuneration policy and R&D performance measures

	(1) order probit model npat	(2) probit model pat val	(3) npat2	(4) probit model pat val2	(5) use
perc_fixed_rem	0.022 (0.148)	(0.042) (0.196)	0.139 (0.210)	0.042 (0.243)	-0.271 (0.187)
perc_rev_rem	0.062 (0.089)	0.137 (0.095)	0.029 (0.111)	0.096 (0.141)	0.194* (0.099)
mtvn_sci	0.015 (0.057)	0.118** (0.059)	-0.043 (0.072)	0.081 (0.066)	-0.099* (0.058)
mtvn_chall	0.117 (0.072)	0.280*** (0.093)	0.168* (0.092)	0.292*** (0.094)	0.282*** (0.081)
mtvn_org	-0.017 (0.048)	-0.135** (0.058)	-0.08 (0.059)	-0.169** (0.072)	-0.065 (0.048)
mtvn_career	0.141*** (0.042)	0.088 (0.070)	0.093 (0.059)	0.114 (0.081)	-0.014 (0.058)
mtvn_rep	-0.024 (0.044)	-0.028 (0.058)	-0.083 (0.059)	-0.079 (0.079)	0.023 (0.053)
mtvn_budget	-0.022 (0.051)	0.021 (0.053)	0.075 (0.062)	0.065 (0.070)	-0.059 (0.063)
mtvn_money	0.007 (0.047)	0.041 (0.060)	0.029 (0.056)	0.02 (0.078)	0.004 (0.058)
sex	0.501 (0.413)	-0.455 (0.417)	1.059** (0.533)	-0.217 (0.543)	-1.057*** (0.352)
lnage	0.525** (0.240)	0.472* (0.275)	0.514 (0.331)	0.864** (0.353)	-0.194 (0.306)
education=2	0.449 (0.292)	-0.017 (0.298)	0.319 (0.360)	-0.069 (0.439)	0.136 (0.379)
education=3	0.163 (0.230)	0.196 (0.233)	0.086 (0.270)	-0.052 (0.341)	0.044 (0.245)
education=4	0.177 (0.227)	-0.011 (0.242)	0.152 (0.283)	-0.322 (0.338)	-0.008 (0.239)
education=5	0.478* (0.272)	0.252 (0.258)	0.296 (0.329)	0.312 (0.387)	-0.405 (0.312)
rdd	0.202 (0.129)	0.075 (0.152)	0.265 (0.170)	0.152 (0.169)	-0.383** (0.150)
seeds	0.194** (0.098)	-0.042 (0.103)	0.246** (0.115)	-0.075 (0.136)	-0.08 (0.137)
explore	0.123 (0.150)	-0.340* (0.189)	0.082 (0.172)	-0.179 (0.234)	-0.137 (0.180)
basic	0.292** (0.115)	0.329*** (0.123)	0.294** (0.148)	0.270* (0.162)	0.034 (0.144)
apply	0.203** (0.095)	0.249*** (0.087)	0.133 (0.105)	0.354*** (0.127)	-0.071 (0.099)
dev	0.222* (0.119)	0.209* (0.113)	0.258* (0.147)	0.309** (0.142)	0.222** (0.109)
lnsales	0.034 (0.037)	-0.008 (0.039)	0.059 (0.046)	0.028 (0.055)	-0.082** (0.039)
pat_stock	-0.042 (0.033)	0.035 (0.042)	-0.077** (0.038)	0.023 (0.040)	0.033 (0.034)
time dummy	yes	yes	yes	yes	yes
US-subclass dummy	yes	yes	yes	yes	yes
Observations	788	604	780	595	778
Log Likelihood	-978	-706.69	-428.51	-315.81	-465.75

Some independent variables omitted from the table include lninventors, lnmanmonth, technical service dummy, and purpose of the project. Standard errors clustered by firms are in parentheses.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%



Table 8 Probit regression and propensity score matching estimates of the effect of firm-reported and employee-reported revenue-based remuneration

Treatment	Dependent variable	Effect	
		probit	PSM
rev_rem	npat2	0.063* (0.033)	-0.005 (0.040)
	pat_val2	0.077** (0.032)	0.059 (0.048)
	use	-0.022 (0.052)	-0.012 (0.044)
perc_rev_rem	npat2	0.010 (0.040)	0.044 (0.039)
	pat_val2	0.034 (0.049)	0.077* (0.043)
	use	0.077* (0.039)	0.086** (0.041)

Nearest neighbor matching was selected as the matching procedure. The treatment effect computed from the probit estimates is based on the mean values for all independent variables.

Robust standard errors in parentheses in probit model and bootstrapped standard errors in parentheses in PSM.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 9 Estimation of revenue-based remuneration policy and R&D performance measures using probit model with instrumental variables

	(6)	(7)	(8)
	probit model with IV		
	npat2	pat_val2	use
perc_fixed_rem	0.04 (0.223)	0.03 (0.265)	-0.249 (0.203)
perc_rev_rem	-0.277 (0.316)	-0.16 (0.378)	0.046 (0.323)
mtvn_sci	-0.05 (0.088)	0.098 (0.081)	-0.062 (0.067)
mtvn_chall	0.254** (0.113)	0.251** (0.104)	0.230** (0.092)
mtvn_org	-0.065 (0.068)	-0.154* (0.086)	-0.057 (0.055)
mtvn_career	0.071 (0.069)	0.031 (0.078)	-0.027 (0.064)
mtvn_rep	-0.084 (0.068)	-0.072 (0.095)	0.052 (0.063)
mtvn_budget	0.022 (0.068)	0.152* (0.083)	-0.067 (0.077)
money	0.073 (0.068)	0.078 (0.086)	-0.008 (0.065)
sex	0.956* (0.499)	-0.106 (0.603)	-1.008*** (0.298)
lage	0.865** (0.387)	0.846** (0.394)	-0.294 (0.357)
education=2	0.475 (0.424)	0.044 (0.517)	-0.086 (0.439)
education=3	0.29 (0.339)	-0.186 (0.423)	-0.297 (0.296)
education=4	0.29 (0.349)	-0.448 (0.413)	-0.33 (0.276)
education=5	0.462 (0.413)	0.132 (0.445)	-0.839** (0.379)
rdd	0.346* (0.187)	0.009 (0.194)	-0.471*** (0.156)
seeds	0.246** (0.121)	-0.415 (0.265)	0.019 (0.158)
explore	0.03 (0.182)	0.263 (0.175)	-0.204 (0.200)
basic	0.216 (0.168)	0.407*** (0.151)	0.145 (0.175)
apply	0.137 (0.122)	0.266 (0.164)	-0.137 (0.107)
dev	0.24 (0.170)	-0.034 (0.230)	0.196* (0.112)
lnsales	0.077 (0.060)	-0.017 (0.045)	-0.024 (0.053)
pat_stock	-0.082* (0.047)	-5.354*** (1.923)	0.072 (0.045)
time dummy	yes	yes	yes
US-subclass dummy	yes	yes	yes
Observations	639	482	639
Log Likelihood	-705.42	-516.13	-730.65

Some independent variables omitted from the table include lninventors,

lnmanmonth, technical service dummy, and purpose of the project.

Standard errors clustered by firms are in parentheses.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 10 Estimation of revenue-based remuneration policy and R&D performance measures among inventors who preferred monetary rewards

	(9)	(10)		(11)	(12)	(13)		(14)
	npat2	probit model		use	npat2	IV probit model		use
		pat_val2				pat_val2		
perc_rev_rem	0.039 (0.140)	0.058 (0.161)	0.093 (0.120)	-0.412 (0.376)	-1.016*** (0.303)	0.672* (0.383)		
perc_fixed_rem	0.483* (0.257)	-0.331 (0.316)	-0.510* (0.295)	0.441 (0.272)	-0.166 (0.322)	-0.45 (0.312)		
mtvn_sci	0.128 (0.098)	-0.011 (0.092)	-0.164** (0.077)	0.061 (0.116)	0.024 (0.093)	-0.190** (0.081)		
mtvn_chall	0.215* (0.123)	0.247** (0.123)	0.283** (0.112)	0.303** (0.147)	0.199 (0.130)	0.235* (0.130)		
mtvn_org	-0.05 (0.074)	-0.165* (0.098)	-0.043 (0.066)	-0.034 (0.086)	-0.148 (0.104)	0.008 (0.075)		
mtvn_career	-0.102 (0.078)	0.115 (0.109)	-0.078 (0.084)	-0.103 (0.087)	0.055 (0.111)	-0.114 (0.090)		
mtvn_rep	0.007 (0.090)	0.083 (0.102)	-0.052 (0.077)	-0.002 (0.104)	0.176* (0.098)	0.003 (0.087)		
mtvn_budget	0.148 (0.091)	0.091 (0.096)	0.077 (0.070)	0.098 (0.101)	0.103 (0.113)	0.113 (0.086)		
sex	0.715 (0.536)	-0.35 (0.544)	-0.939 (0.587)	0.568 (0.523)	-0.887 (0.600)	-1.084* (0.614)		
lage	0.278 (0.413)	0.852* (0.438)	0.112 (0.339)	0.666 (0.467)	0.693 (0.473)	-0.445 (0.383)		
education=2	-0.572 (0.595)	-0.866 (0.585)	0.216 (0.472)	-0.176 (0.675)	-0.79 (0.680)	-0.267 (0.571)		
education=3	0.204 (0.319)	-0.12 (0.441)	0.322 (0.329)	0.581 (0.392)	-0.146 (0.633)	-0.447 (0.418)		
education=4	0.308 (0.329)	-0.675 (0.431)	0.262 (0.349)	0.559 (0.371)	-0.743 (0.591)	-0.408 (0.432)		
education=5	0.452 (0.376)	-0.041 (0.505)	0.088 (0.419)	0.797 (0.494)	-0.04 (0.670)	-0.594 (0.578)		
rdd	-0.101 (0.216)	0.332 (0.259)	-0.422** (0.201)	0.034 (0.255)	0.016 (0.279)	-0.550*** (0.201)		
seeds	0.293* (0.156)	0.041 (0.173)	-0.063 (0.156)	0.204 (0.168)	0.014 (0.181)	-0.004 (0.192)		
explore	0.099 (0.238)	-0.099 (0.281)	-0.082 (0.248)	-0.075 (0.237)	-0.408 (0.326)	-0.087 (0.315)		
basic	0.202 (0.182)	0.134 (0.240)	-0.159 (0.213)	0.232 (0.220)	0.203 (0.318)	0.13 (0.270)		
apply	-0.003 (0.162)	0.569*** (0.167)	-0.083 (0.139)	0.026 (0.208)	0.816*** (0.186)	-0.352* (0.188)		
dev	0.328* (0.185)	0.273 (0.170)	0.172 (0.150)	0.341 (0.215)	0.249 (0.171)	0.122 (0.155)		
lnsales	0.039 (0.052)	0.126* (0.067)	-0.08 (0.051)	0.091 (0.064)	0.230*** (0.070)	-0.034 (0.070)		
pat_stock	-0.047 (0.043)	0.016 (0.051)	0.05 (0.043)	-0.097* (0.052)	-0.01 (0.044)	0.066 (0.059)		
time dummy	yes	yes	yes	yes	yes	yes		
US-subclass dummy	yes	yes	yes	yes	yes	yes		
Observations	504	387	499	415	318	415		
Log Likelihood	-265.51	-198.15	-292.05	-443.56	-318.69	-454.8		

Some independent variables omitted from the table include lninventors, lnmanmonth, technical service dummy, and purpose of the project. Standard errors clustered by firms are in parentheses.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Table 11 Firms paying invention remuneration and average payouts

Year	Total Number of Firms	Average Payout per Firm (¥million)	No. of Firms Paying Remuneration	Percentage of Paying Firms	Average Payout per Paying Firm (¥million)
2003	694	7.38	563	81.1%	9.10
2004	694	7.61	567	81.7%	9.32
2005	694	8.77	577	83.1%	10.55
2006	694	9.79	582	83.9%	11.68
2007	694	11.72	569	82.0%	14.30

Note: The table exhibits a balanced panel including only those firms that were surveyed every year from 2003 to 2007.

Source: Survey of Intellectual Property Related Activities, Japan Patent Office.