

23 Do Compensation Systems for Employee Inventions Increase Incentives for Researchers? — Evidence from Japanese Panel Data —

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This research empirically analyzed whether compensation systems for employee inventions that are currently implemented by companies actually lead to R&D results. A detailed questionnaire survey, targeting 310 manufacturing companies listed on the first section of the Tokyo Stock Exchange, was conducted about the status of implementation of compensation systems for employee inventions. This was in order to investigate whether such compensation systems have a positive effect on the number of US patents and the number of patents adjusted for the number of forward citations. Estimation results revealed that both compensation systems based on overseas filing/registration and compensation systems based on performance such as sales and royalty income are effective in increasing the number of US patents, but that they do not contribute to increasing the number of patents adjusted for the number of forward citations. This outcome indicates that compensation systems for employee inventions are effective in increasing the number of patents rather than increasing the quality of patents. In other words, it suggests that compensation for employee inventions is effective to a certain extent as performance-based pay but that this effect is limited.

I Introduction

The purpose of this research study is to quantitatively grasp the outline of compensation systems for employee inventions that are currently implemented by companies, and then empirically analyze whether such systems actually lead to better R&D results.

Since most patent applications currently pending are filed by organizations such as companies and universities, the issue of incentives for researchers in employment to create inventions is extremely important. However, while R&D incentives for companies have been frequently addressed in theoretical and empirical analyses so far, incentive systems for researchers employed by companies have not yet been sufficiently studied.^(*1) Recently, along with the increasingly high level of R&D, the funding and resources supplied by companies have become increasingly important. Nevertheless, incentives for researchers who are directly involved in the process of making inventions are still critical to R&D.

The Japanese Patent Law provides that companies shall pay a “reasonable remuneration” for inventions transferred from their employees who have made the inventions. Therefore, many Japanese companies implement compensation

systems to provide compensation for each invention based on its performance. In particular, due to the recent increase in the number of lawsuits filed by employees for a “reasonable remuneration,” the number of companies that implement compensation systems for employee inventions as a means to avoid such lawsuits is also increasing.

The purport of this legal provision on employee inventions is to compensate inventors with a part of the profits arising from the inventions in order to motivate them to make those inventions, thereby contributing to development of industry, which is the primary purpose of the Patent Law.^(*2) Furthermore, as performance-based salary systems have recently been introduced for various types of occupations, companies could benefit from implementing performance-based compensation systems, irrespective of whether the law requires such systems.

However, there are some factors that might prevent compensation systems for employee inventions from producing the expected effects. According to the standard contract theory, at least, the higher the uncertainty regarding inventions or evaluation risk, the less effective the performance-based pay.

Based on the above, this research study

(*1) Agihon and Tirole (1994), an exceptional study.

(*2) Refer to the statements of JPO Commissioner Shinichiro Ota at the Commission on Economy and Industry of the House of Representatives on November 8, 2002.

analyzes statistically whether compensation systems for employee inventions increase incentives for researchers and contribute to the company's success.

II Effectiveness of Compensation Systems for Employee Inventions

Compensation for employee inventions is paid based on research results achieved by individual employees and therefore can be regarded as a kind of performance-based pay.

According to contract theory, an effective way of motivating employees is to pay them salary based on performance in addition to a fixed salary. Therefore, in order to secure highly-motivated employees, companies will find incentives to implement performance-based salary systems. In other words, if companies could benefit by paying researchers salary based on performance, they would implement performance-based compensation systems, irrespective of the provisions of Section 35 of the Patent Law.

However, as mentioned above, implementing performance-based salary systems in the R&D field may not be beneficial from the perspective of contract theory due to the following factors.

The first factor is the very high uncertainty of inventions. According to the standard contract theory, if performance risk is high, increasing the amount of a fixed salary is more beneficial to both companies and employees than paying a salary based on performance, because as long as employees have the tendency to avoid risk, then the higher the uncertainty, the lower the marginal utility of the performance-based salary system.^(*3) Also, such a salary payment system susceptible to uncertainty is not as beneficial to companies as might be expected.^(*4)

In reality, only a limited number of researchers are so productive as to file many patent applications. It is said that the number of

researchers who obtain patents during a certain term, n , decreases in proportion to $1/n^2$ according to Lotka's Law (Narin and Breitman, 1995). Furthermore, there exists a considerable variation in respect of the value of patents; 10% of all patents account for 90% of the total value (Scherer and Harhoff, 2003). In the pharmaceutical field, it is extremely difficult to develop commercial drug products from R&D results, and most researchers are unable to develop commercial products and make little contribution to profits before they end their careers in pharmaceutical companies. In addition, whether patents actually contribute to sales or profits largely depends on the quality of other related inventions and marketing efforts, which are out of the control of inventors. Thus, since invention-related activities are affected by not only individual researchers' efforts but also contingency and other various elements, employees engaged in such activities may have a far higher uncertainty of the outcome of their efforts than those engaged in other types of occupations such as marketing and automobile assembly.^(*5)

The second factor is the difficulty in evaluating performance that qualifies for compensation. In a large-scale survey by Marsden, et al. (2002) regarding the implementation of the performance-based salary system for public employees in the United Kingdom, it was verified that performance-based pay was generally effective for white-collar employees but that it might rather decrease incentives for them if they were dissatisfied with evaluation of their performance.

As a "reasonable remuneration," employees require compensation to be paid not only at the time of filing of a patent application and the time of patent registration but also based on the actual performance of the patent, e.g. sales, profits, and royalty income arising from the patent. However, with the exception of certain industries including the pharmaceutical industry, a single product

(*3) Fumio Otake (2005) explains the reason why the court decision granting Mr. Shuji Nakamura 20 billion yen in performance-based compensation is supported among researchers who generally do not desire performance-based pay, by applying the principle under which people buy lottery tickets. People buy lottery tickets because they have the tendency to overestimate the probability of success beyond an objective level, even though the probability is actually very low. This also applies to performance-based pay: researchers overestimate the probability of success in making inventions, even though the probability is actually very low, and desire performance pay despite a low likelihood of earning it. According to this theory, companies would be able to reduce salary costs and increase profits by offering such a performance-based salary system.

(*4) Prentergust (2001) theoretically analyzed the fact that the performance-based pay system was implemented for occupations with higher uncertainty, which runs contrary to contract theory, and found that performance-based salary was paid to cover achievements made by agents that often could not be sufficiently monitored due to uncertainty.

(*5) The effectiveness of performance-based pay for employees engaged in particular occupations, such as marketing and assembly operation, has been verified in many papers; for details, see Prentergust (1999).

generally involves multiple patents, and it is difficult to assess the degree of contribution of each patent. Where one product involves hundreds or thousands of patents, such as seen in the case of semiconductors and LCDs, it is effectively impossible to assess the degree of contribution of each patent to sales or profits. Such difficulty in patent evaluation is clearly reflected in the fact that in Germany, despite the guidelines for compensation calculation, disputes endlessly occur between inventors and companies. It is also confirmed by a questionnaire survey which showed many employees to be dissatisfied with the evaluation of their inventions.

Compensation systems for employee inventions have other problems too, including multi-task issues, a sense of inequality between employees engaged in research fields where making inventions is relatively easy and those in fields where it is not, and delays in payment of compensation due to the time lag between when the inventions are made and when they achieve performance.

III Past Research Surveys

The effect of performance-based remuneration has not yet been sufficiently studied, except for the case where Haftel and Martin (1993) conducted a survey targeting 48 high-technology companies in the State of Connecticut and found that both pecuniary compensation and non-pecuniary compensation (e.g. awards) were effective in increasing the number of patents. However, they pointed out that payment of a large amount of compensation over \$50,000 was only effective for small-sized companies including venture companies, suggesting that many researchers in venture companies prefer pecuniary compensation. Lach and Schankerman (2004) analyzed whether the system to pay university researchers compensation in proportion to royalty income would increase a university's total royalty income. They found that an increase by 1% of the royalty share for researchers would increase royalty income by 4.5%. They also found that this effect was produced by two factors—increased incentives for university researchers and the flow of researchers who prefer pecuniary compensation into universities.

Savitsky (1991) conducted a questionnaire survey targeting 203 US companies, and found that about 91% of all target companies provided a fixed amount of compensation for the filing of a patent application, whereas companies providing

compensation for remarkable inventions and those providing compensation based on profits only accounted for 15% and 7% respectively. Savitsky pointed out that in the United States, although the transfer of employees' inventions was effected by a contract between companies and researchers, performance-based compensation systems were adopted by only a limited number of companies, and this very fact suggested that performance-based compensation systems might not be effective. Meier (1998) pointed out that payment of compensation at the time of transfer of inventions as required under the German law on employee inventions would increase costs incurred by companies in obtaining patents and also produce other adverse effects, such as disputes between inventors and companies over payment of compensation, prevention of the exchange of information among researchers, and researchers' tendency to prevent others from making inventions that would replace their own invention. Nagaoka (2006) presented problems with compensation systems, such as uncertainty of inventions, evaluation risk and costs, and multi-task issues, pointing out that researcher evaluation systems should basically be diverse and that limiting the scope of options by law was inappropriate.

In an attempt to investigate the effect of performance-based compensation systems, Harhoff and Hoisl (2004) and the Institute of Intellectual Property (IIP) (2003) conducted questionnaire surveys targeting inventors. Harhoff and Hoisl targeted 3,346 inventors whose inventions had been filed for patents at the European Patent Office (EPO). In the survey, 60% of the respondents regarded the German law on employee inventions as providing R&D incentives, whereas 30% evaluated the law negatively. Among the reasons for the negative view, a "small amount of compensation" was chosen by the most respondents, at 33.6%, with an "opaque calculation method" chosen by 32% and "delays in payment" by 15.3%, indicating that most respondents found problems with the amount of compensation. The IIP (2003) targeted 2,394 Japanese inventors in its questionnaire survey. Among the possible R&D incentives, "growth of the company's business," "better evaluation as a researcher," and "compensation" ranked first to third, suggesting that pecuniary compensation is not the most effective means to increase R&D work incentives for inventors. In response to the question as to whether or not compensation provides incentives, 60% of the

respondents answered positively whereas 25% answered negatively. Among the reasons for the negative view, the “small amount of compensation” ranked first, followed by “delays in payment.” This also suggests, as the survey by Harhoff and Hoisl (2004) indicates, that most inventors are dissatisfied with the amount of compensation.

IV Formation of Hypotheses

In light of the problems with compensation systems for employee inventions and the past survey results described above, this research study examines the hypotheses shown below. The first hypothesis is as follows.

Hypothesis 1: Compensation systems based on performance such as sales, profits, and royalty income increase the number of patents but do not have any significant effect on the acquisition of valuable patents

Performance-based compensation systems may increase incentives for researchers. However, as mentioned above, the effect is limited because of the high uncertainty of inventions and high evaluation risk.

On the other hand, under compensation systems based on filing/registration, compensation is to be paid for inventions when they result in the filing of patent applications or registration of patents, and therefore, such compensation systems involve lower evaluation risk than performance-based compensation systems. From this perspective, another hypothesis is formed:

Hypothesis 2: Compensation systems based on filing/registration greatly contribute to increasing the number of patents because of lower evaluation risk than that for performance-based compensation systems^(*6)

However, under compensation systems based on filing/registration, a fixed amount of compensation is paid for inventions when they result in the filing of patent applications or registration of patents, irrespective of the value of the patents. Therefore, such compensation systems may not increase the number of patents that are more valuable than being merely qualified for compensation. This leads to another hypothesis:

Hypothesis 3: Compensation systems based on domestic filing/registration do not increase the number of overseas patent applications or overseas patents

This research study uses the number of US patents as an indicator of performance. Compensation systems based on domestic filing/registration are not expected to increase the number of patents that are so valuable as to be filed or registered overseas.

In addition, the following hypotheses are also examined:

Hypothesis 4: Compensation systems based on royalty income are more effective in increasing the number of patents because of low evaluation risk

Hypothesis 5: If researchers are more conscious of uncertainty of inventions than evaluation risk, then in the pharmaceutical industry, performance-based compensation systems increase incentives for researchers and lead to valuable inventions

Compensation systems based on royalty income involve low evaluation risk because each patent is evaluated through negotiation with the licensee. However, the number of patents licensed to third parties is smaller than the number of patents used for in-house exploitation, and such licensed patents are highly likely to be left unused by licensees. Even in the pharmaceutical industry, although it is relatively easier than in other industries to evaluate individual patents because of strong linkage between patents and products, making inventions that can result in commercial products is an extremely difficult task. The last two hypotheses have in common low evaluation risk compared with uncertainty of use or inventions. If these hypotheses are successfully verified, it would follow that researchers are more conscious of evaluation risk than uncertainty of inventions.

V Outline of the Questionnaire Survey and the Status of Implementation of Compensation Systems for Employee Inventions

In this research study, a questionnaire survey was conducted for the purpose of investigating the status of implementation of

(*6) See Supplementary note 1 for the impact uncertainty of invention and evaluation risk have on the effectiveness of compensation systems for employee inventions.

compensation systems for employee inventions. The survey targeted 836 manufacturing companies that were listed on the first section of the Tokyo Stock Exchange at the end of March 2005. The questionnaire sheet was sent on July 21 and the deadline for response was set at August 31. Among the targeted companies, 360 companies responded to the questionnaire (response rate: 43.1%). A final analysis was made with respect to 347 companies, with two companies excluded that had not obtained any patent in the past 15 years and 11 companies that refused to answer some major questions.

The number of companies that implemented compensation systems based on domestic filings was 248 (82%) in 1990 and 323 (93%) in 2005 respectively, indicating that a significant number of companies implemented compensation systems based on domestic filings. This result corresponds with the result obtained from the questionnaire survey conducted by the IIP (2003).^(*) The number of companies that implemented compensation systems based on domestic registration was slightly lower than the number of those implementing compensation systems based on domestic filings, but gradually increased from 254 (73%) in 1990 to 288 (83%) in 2005.

The number of companies that implemented compensation systems based on overseas filing/registration increased during the period from 1990 to 2005, from 45 (13%) to 75 (22%) for filing and from 56 (16%) to 91 (26%) for registration, whereas the percentage of companies implementing overseas compensation systems was smaller than that of companies implementing domestic compensation systems. Among the finally targeted companies, 310 companies owned US patents, and at least 93% of them obtained more than one US patent during the period from 1988 to 2002 and were likely to be actually operating business overseas. Nevertheless, there are only a limited number of companies that implemented compensation systems for overseas filing/registration. This may be because a generally accepted view has not yet emerged regarding whether a "reasonable remuneration" under Section 35 of the Patent Law shall also be required for the transfer of foreign patents. If Section 35 also covered overseas performance, more companies would introduce overseas compensation systems in the

future.

In this questionnaire, five options were offered in respect of the amount of compensation for filing/registration: "less than 5,000 yen," "5,000-10,000 yen," "10,000-30,000 yen," "30,000-100,000yen," and "100,000 yen or more." In 1990, most companies offered a very small amount of compensation for filing, 39% offering less than 5,000 yen and 85% offering less than 10,000 yen, whereas in 2005, the proportion of those offering less than 5,000 yen and less than 10,000 yen declined to 14% and 57% respectively, suggesting that many companies increased the amount of compensation for filing. This trend is also seen in respect of the amount of compensation for registration: the proportion of companies offering less than 10,000 yen declined by two-thirds, from 30% in 1990 to 11% in 2005. The number of companies offering 100,000 yen or more as compensation increased from two in 1990 to 11 in 2005.

The next topic is the trend in the number of companies that implemented performance-based compensation systems, under which compensation is paid when inventions actually achieve results, e.g. patents contribute to the company's sales and profits or produce royalty income. The number of companies that implemented performance-based compensation systems increased from only 180 (52%) in 1990 to 274 (71%) in 2005. However, the number was far smaller than the number of companies that implemented compensation systems based on domestic filing/registration. From 1990 to 2005, the number of companies that implemented performance-based compensation increased slowly and the rate of increase also increased slightly since the second half of the 1990s. This trend seems to be in line with the increase in the number of lawsuits filed by employees since the *Olympus* case in 1995. In the first half of the 1990s, the number of companies that introduced performance-based compensation systems peaked in 1992. This trend seems to correspond to the fact that the district court made a decision on the employee's lawsuit against Kaneshin in that year, and lawsuits had also been filed by employees against Zojirushi and Gosen for a "reasonable remuneration" in the previous year.

Looking at the trend in the number of companies that implemented performance-based compensation systems by type of performance,

(*) Among the respondents to the questionnaire survey conducted by the IIP in 2003, more than 90% of large companies implemented compensation systems based on domestic filings.

throughout the survey period, the number of companies that implemented compensation systems based on contribution to the company's sales and profits or contribution to revenues from the company's products was the largest (167 in 1990, 283 in 2005). The number of companies that implemented compensation systems based on royalty income (including royalty income under cross-licensing) was 133 in 1990, accounting for 80% of the companies that implemented compensation systems based on sales/profits. That number increased to 246 in 2005, accounting for 87%, indicating that many companies introduced compensation systems based on licensing.^(*8)

In this questionnaire, six options were offered in respect of the maximum amount of performance-based compensation: "less than 100,000 yen," "100,000-1 million yen," "1-10 million yen," "10-100 million yen," "10 million yen or more," "no upper limit." The largest amount of compensation offered by each company for any of the three types of performance was regarded as the company's maximum amount of compensation. Until 2000, the companies that offered less than 10 million yen accounted for 60%, and the remaining 40% only offered 1 million or less. However, in 2005 when the amendment was made to the provisions on employee inventions under the Patent Law, the number of companies that abolished the upper limit rapidly increased. This may be because the legal amendment increased the possibility that setting an upper limit to the amount of compensation would be regarded as a violation of the requirement for "reasonable regulations."

There are three ways of paying compensation based on performance: paying a standard amount of compensation upon in-house exploitation of patents, irrespective of performance; paying a fixed amount of compensation according to the degree of contribution of the performance; and paying an amount of compensation in proportion to the performance by using the degree of contribution as a coefficient. With respect to compensation for contribution to the company's sales and profits, the companies that offered a fixed amount of compensation according to performance accounted for 22% in 1990 and 25% in 1995, whereas the companies that offered an amount of compensation in proportion to performance accounted for 19% in 1990 and 20% in 1995.

During the 1990s, for in-house exploitation, the number of companies applying fixed-rate payment had been larger than the number of companies applying proportional payment. On the other hand, with respect to compensation upon receiving royalty income, the companies that offered a fixed amount of compensation according to performance accounted for 10% in 1990 and 12% in 1995, whereas the companies that offered an amount of compensation in proportion to performance accounted for 24% in 1990 and 25% in 1995. The number of companies applying proportional payment was significantly larger than the number of companies applying fixed-rate payment. The fact that fixed-rate payment is applied more frequently for in-house exploitation than for licensing may suggest the difficulty in evaluating the degree of contribution in the case of in-house exploitation

VI Estimation Methods

This research study applied the knowledge production function in order to verify the effect of the implementation of compensation systems. The knowledge production function, which was advocated by Griliches and Schankerman (1984), shows the rate of contribution of R&D investment to the increase in knowledge, and generally uses the number of patents as a proxy variable for knowledge. This research study aims to examine the impact of compensation systems on the increase in knowledge by inserting variables relating to compensation systems in the knowledge production function.

VII Estimation Results

Compensation systems based on domestic filing/registration do not contribute to increasing the number of US patents whereas compensation systems based on overseas filing/registration increase the number of US patents. This suggests the possibility that compensation systems based on filing/registration may increase the number of patents that are valuable enough to be qualified for compensation but do not lead to the acquisition of more valuable patents. Compensation systems based on performance such as sales and royalty income are effective in increasing the number of US patents; however, as in the case of compensation systems based on filing/registration, they do not contribute to

(*8) For the implementation status by industry, see Appendix 4.

increasing the number of patents more valuable than those merely qualifying for compensation. These results suggest that compensation systems are effective in increasing the number of patents rather than increasing the quality of patents.

If focus is placed on the effect of increasing the number of patents, compensation systems based on filing/registration are more effective than performance-based compensation systems. However, compensation systems based on royalty income and performance-based compensation systems in the pharmaceutical industry involve low evaluation risk, and therefore they are as effective as or more effective than compensation systems based on filing/registration. This suggests the possibility that performance-based compensation systems are more effective where evaluation risk is low. This corresponds with the fact that most inventors who are dissatisfied with compensation systems complain about the amount of compensation or the calculation standards.

Performance-based compensation systems are less effective in companies that implement such systems only for the passive reason of complying with Section 35 of the Patent Law. Award systems are also effective in increasing the number of patents.

Consequently, the following implications can be obtained from this research study.

The research study successfully verified that compensation systems implemented by Japanese companies are effective to a certain extent in increasing their motivation toward innovations. This corresponds with the view shared among companies and inventors that compensation systems lead to increasing researchers' motivation to make inventions. However, it is also suggested that the effect of compensation systems is limited, and they are more effective in increasing the number of patents rather than increasing the quality of patents. Compensation systems may not function sufficiently to increase incentives for researchers in such companies that implement the systems only for the passive reason of complying with Section 35 of the Patent Law, and this analysis result suggests that it is inappropriate to place excessive expectations in the effect of compensation systems for researchers.

These results suggest the possibility that the recent rise in the amount of compensation may not function effectively to increase incentives for researchers.

This research study was also successful in

verification of contract theory. Past empirical analyses regarding the effectiveness of performance-based pay systems only targeted a limited range of occupations, such as CEOs and marketing staff, workers on production lines, and professional athletes (Prentergust, 1999). In this respect, this research study that attempted to investigate the effect of compensation systems for researchers can be regarded as an empirical analysis on performance pay systems that has never previously been made. Furthermore, the study result that performance-based pay systems cannot function effectively where evaluation risk is high empirically supports contract theory.