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Causal Effects of Software Patents on Firm Growth: Evidence from a policy reform in Japan*

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Abstract

The patentability of software dramatically expanded in the United States, European Union, and Japan during the 1990s. Using the exogenous policy change, this paper identifies the causal effect of filing software patents through the policy reform on the firms' subsequent growth. We find that small software firms as well as large firms increase software patent applications due to the expansion of patentable subject matter. However, the results show that such patent explosion has an insignificant effect on larger firms' performance, while it improves the subsequent performance of small and medium-sized enterprises (SMEs). We also find that the number of patent attorneys in the same prefecture has a significant effect only for small firms, which is the main driving factor of improving the firm's performance. These results suggest that broadening the scope of software patents does contribute to innovation, especially for SMEs with a small patent portfolio and business assets through decreasing the cost of patenting activity.

Keywords: Software patent, Software, Patent thicket, Firm performance
JEL Code: O34 L86 L22

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1. Introduction

The purpose of patent law is to encourage inventions and thereby contribute to the development of industry. However, there is still a controversy on whether and how the patent law actually contributes to the purpose. Focusing on the expanding of software patent, this paper examines the causal effect of acquiring patents, since the patentability of software has attracted much policy attention across major countries.

Boldrin and Levine (2010) point out that major innovation in software were brought before the expanding of software patent. Further, a lot of software patents filed cause "patent thicket" i.e. too much fragmented essential technology or too many patents prohibitory increase risk of infringement and transaction cost for licensing negotiation and strategic patenting (Hall and MacGarvie 2006). Bessen and Hunt (2007) show the amendment of laws in the U.S. does not promote firms' R&D activities and simply increases software patents. In contrast, Lerner and Zhu (2007) confirms that the increased software patenting does have a positive effect on sales and the R&D expenses of a firm. Merges (2006) suggests that software patents are not a disincentive to new start-ups. Rather, patent activity presents a positive correlation with corporate performance (e.g., income per employee). Cockburn and MacGravie (2011) show that although intensive patents in narrowly defined technology class (patent thicket) deter new entrances, startup having patents can easily enter the markets. They conclude that while software patent increase transaction cost, this doesn't necessarily mean negative for innovative activities among companies. One of the sources of the inconsistency of the results among the previous studies would be the endogeneity. The firms with higher performance should have stronger incentive to obtain patents. Moreover, patenting should increase the appropriability and thereby improve the performance.

This paper identifies the causal effect of the policy change that expanded software patent, exploiting the exogeneous variation of the number of patent attorneys in the same prefecture and the prior experience of filing non-software patent applications. The scope of software patent has expanded in Japan, following expansion of patentability for software through the court decision in the U.S. According to the policy reform, the number of software patent applications has significantly increased in Japan (Motohashi, 2008). However, few research has evaluated the impact of the policy change. To address the effect of policy change, the difference in difference estimation might be one of the useful candidates of methods. We first employ this method for analyzing the influence of "program patent" which newly became patentable in our estimation period.

After program patents came into effect in 1997, a computer program can be protected even if it is not embodied to any specific hardware. Therefore, it is beneficial mainly to the firms providing packaged software (treatment group), while it has less influence on the firms manufacturing only hardware (control group). We can exploit this difference to analyze the effect of policy change. However, policy change is also brought by other economic factors such as development of the industry and sophisticated technology, which can cause spurious correlation. Further, unobserved firm heterogeneity can also affect the packaged software firm's decision on whether it applies for a program patent, which bias the estimation results. To solve this problem, we exploit two instrument variables: the number of patent attorneys located in the same area and the number of non-software patent applications before the policy change.

If a reliable patent attorney office is located near the firms, it can reduce the firms' costs to apply for the patents especially in the newly patentable field since the firms easily access and consult the attorney. Therefore, geographical closeness to an attorney would increase the probability of filing patent applications while it does not directly affect the performance of the firm. Another instrumental variable, the prior number of non-software patent applications which was employed in Cockburn and MacGarvie (2011), can be correlated with the firms' propensity to file patents while it has less correlation with the firms' subsequent performance in the software-related business.

Focusing on the Japanese policy change has some advantages. First, previous researches tend to converge on US software industry. While software industry in US is prominent and successful, it is not necessarily a good experiment for other countries since the US case is too unique for them. Moreover, patentability of software is quite different across countries even in US, EU and Japan. In general, USPTO has generous criteria for patentability of software and EPO has the strictest criteria one, where JPO takes an intermediate position between them. Therefore, Japanese experience can provide valuable evidence for the countries considering the direction of patent policy. Furthermore, since the recent US courts tend to limit the scope of the software patent, importance of the examination on Japanese policy reform can be more significant.

Our results show that the sample firms increase the number of applications for program patent which was newly acceptable since 1997 and that such patent application increases their performance measured by software sales and employee growth. We also find that such positive effect of patent application was observed only for the small and medium sized firms, though the program patent application has insignificant effect on the large sized firms. This result suggests that large firms have protected their software-related inventions by combining it with the hardware even before the policy change, so that the policy reform only changes the technology filed (program patent) that the large firms apply for and does not affect their performance (or positive effect is canceled out by the negative effect such as patent thicket). On the other hand, most SMEs could not protect their inventions before the policy change since they were not engage in manufacturing hardware which makes the positive effect more significant: positive effect of acquiring newly acceptable program patent is observed in the extensive margin, not in the intensive margin.

The rest of the paper is organized as follows. Section 2 summarizes the history of software protection in Japan, and Section 3 provides an overview of the data. We present our estimation strategy in Section 4, and provide the results in Section 5. Finally, Section 6 concludes the study.

2. History of Software Protection in Japan

The Patent Act of Japan defines invention as the "highly advanced creation of technical ideas utilizing the laws of nature". Traditionally, there was a debate over whether computer programs can be construed as utilizing the laws of nature. On another note, the patentable subject matter in Japan is categorized into a "product" and a "method". Therefore, in order for a computer program to have patent protection, that invention must be determined as utilizing the laws of nature and be either a "product" or a "method"[1].

Under the Patent Act, 2002, a computer program itself is treated as a "product" and is a subject of protection. Until that time, examination criteria and guidelines had been gradually revised. Table 1 shows the milestones of such revisions since the 1990s. Under the Microcomputer Patent Guidelines announced in 1982 patentability of program were limited to those utilize the laws of nature in the software-driven information processing itself. For example, microcomputer-controlled programs in a rice cooker were protected as a "control apparatus". The revision of examination criteria in 1993 interpreted the computer programs that do not utilize the laws of nature in their information processing, but use hardware resources, as utilizing the laws of nature. Nevertheless, this revision didn't include "storage medium with program recorded" from the patentable subject. Therefore, in order to protect the program itself, such an invention still needed to be protected as apparatus integrated with hardware. For example, if a firm desired to protect software that realized a document search function, the firm would have had to patent the software as "document search apparatus". In this case, if another firm was using or selling similar software in the form of CD-ROM, the firm would not have been able to directly exercise the right.

The Guidelines released in 1997 revised this point; "storage medium with program recorded" became describable in the claims as an invention of "product." The advancement of information communications technologies in recent years brought about the selling of software over the internet. As the protection for storage media could not accommodate such transaction types, the examination criteria was again revised in 2000 (applicable to patent applications in and after January 2001), recognizing the program itself as the subject of protection. The amendment of the Patent Act in 2002 specified that a computer program itself is to be treated as a "product".

[1] When an invention is protected as a "product," the production, use, assignment, import or export, and offer for assignment of the invention are regarded as the practice of the invention, whereas when an invention is protected as a "method", only the use of that method is the practice of the invention.

Among these revisions, this study pays particular attention to the revision in 1997 for the purpose of identifying the impact of the policy change[2]. This reform has advantage for the evaluation of the impact since it was the first time that the patent law protects software program apart from hardware. Due to this separation from hardware, we can implement the Differences in Difference method to identify the effect of policy change between the software firms engaging hardware manufacturing and the ones operating only in the packaged software business.

[Table 1]

3. Data

3.1. Data Sources

We use the two data sources here; patent data and software firms' business activity data. Our patent data is obtained from "IIP Patent Database" provided by Institute of Intellectual Property.[3] The business activity data of software firms is obtained from "Comprehensive Register of Information-processing Service Firm" (CRISF, hereafter) provided by Ministry of Economy, Trade and Industry (METI). It includes firm-level rich data such as sales share of packaged software and customized software, the number of system engineer and the number of programmers. The database contains around 1600 firms every year, though the registration of the database is on the voluntary basis. Our sample period is limited to the 1996-2003 due to the availability of electronic data. We matched patent data to these firms, using firms' (applicants') harmonized names and addresses.

We start with some descriptive information on our dataset. First, Table 2 compares the sales and the ratio of its components with a fundamental statistical survey "Survey of Selected Service Industries" for information service industry (SSSI hereafter) conducted by METI based on the approval from the Minister of Internal Affairs and Communications for which the respondents have obligation to report.[4] Table 2 shows the sales and components ratios for all sample firms of CRISF (1,705 firms in 2003) and SSSI (7,380 firms in 2003).[5]

According to the SSSI, the aggregate sales of software service firms in Japan is 14,170.6 billion yen and the total sales of our sample (CRISF) is 11,108.8 billion yen. That is, our sample covers about 78.4% with the sales base. The distribution of sales by business categories is not so different between both samples which indicates that our sample is not biased from the population

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[2] Prior studies (Lerner and Zhu, 2007; Yamauchi and Onishi, 2009) evaluate the impact of change in patent policy using the DID approach, which a priori classify their sample into treatment group and control group.

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

[4] The parent population of the Survey of Selected Service Industries was changed from the 2006, along with the division of the information service industry into software industries and information processing and provision industries. In addition, the survey was changed from a complete count survey to a sampling survey in 2009.

[5] We integrate the business categories of two surveys into a comparable form, since the terms used for the categories have some differences.

in terms of business category, though the number of firms in this study is relatively small. The customized software service is the largest software business category in Japan. The share of the sales for packaged software is 14.1% for our sample while it is 10.2% for the population. We see large difference in the share of information processing between our sample and population. However, our identification relies mainly on the difference of the firms in terms of the engagement in the packaged software service.

[Table 2]

3.2. Software and Program patents

The first challenge to analyze the effect of policy change in this study is an identification of software patent in the IIP Patent Database. According to the previous studies, there are two types of methods for the identification. One is a keyword classification (Bessen and Hunt, 2007) and the other is technological classification using IPC or US Patent Classification (Motohashi 2008; Mann and Sager 2007; Graham and Mowery 2003). Some papers use the combination of these two methods (Hall and MacGarvie 2006; Suzuki 2009).[6] To focus only on the strong points of both methods, we also employ the combination of two methods. Based on Suzuki (2009), we add the IPC sub-groups G06F17 and G06F19 to the definitions of Graham and Mowery (2003) (IPC G06F 3/ - 12/, G06K 9/, 15/, H04L 9/). We also add the game-related IPCs A63F13 and A63F9 which are considered to be important for Japanese software firms. Furthermore, we include the patents that have the keywords “recording medium”, “program”, “system” or “software” in the title of inventions.

Finally, we distinguish the “program patent” which became patentable in 1997 from the other software patents including those only with hardware which had been originally patentable since 1993. We define program patent as the software patents that includes the word “program” in the title of the invention. The propensity of the sample firms to file a program patent is naturally affected by the policy reform in our estimation period, while the number of whole software patent applications would be less sensitive. Figure 1 shows the share of the firms that file at least one software patent application. In this figure, upper line shows the share of the firms filing “software patent” without limiting to the category of software patent, whereas the lower line depicts the percentage of the firms filing “program patent”. We find that, among our sample on average, only 7.0% of the firms file software patent applications. This fact is consistent with the results of Mann and Sager (2007) that most of the software start-ups in the U.S. do not have patents[7]. The percentage of firms applied for software patents shows a rapid increase in 2000, and then it

[6] Layne-Farrar (2005) examines the definition of software patent.

[7] Among their 877 sample, the number of firms that obtain patents during a period of 5 to 8 years after acquiring venture capital is merely 212 firms, and the average number of patents held by those firms is 2.92.

decreases after 2002. This fluctuation may be caused by the temporary prevalence of the applications for business model patent during 2000-2001 in Japan.

Table 3 compares the growth rate of sales, employment and SE and programmer between the firms that start filing program patents and those that do not, respectively. We divide the sample into the large firms with more than 300 employees and the SMEs with less than 300 employees. We see that growth rates are higher for the non-patentees among the large firms, while they have higher value for the patentees among the SMEs. This result implies the higher importance of patent protection of new subject matter for the smaller firms.

[Figure 1]

[Table 3]

4. Empirical Strategy

To examine the impact of filing a software patent application on firm growth, we must control for the endogeneity of patent application. For example, when the firm has higher technology capability, they can have higher propensity to file a patent and at the same time it can have higher growth rate. In this case patent application is likely to correlate with the growth rate, even if this does not indicate the causality.

For our identification of the causal effect, we rely on the Difference in Differences (DID) specification, assuming that policy reform in 1997 which newly accepted the program patent, is exogenous like Huang et al. (2013). However, a policy change is sometimes induced to respond to the requests by the industry according to the development of industry and technological progress. If this is the case, the estimation results might overestimate the impact of expanding the scope of software protection. Furthermore, even if the policy reform is entirely exogenous, there is a possibility that the firm's decision on filing a patent application after the policy change might depend on an unobserved heterogeneity of firms such as an invention capability.

To avoid these potential endogeneity, we employ two-stage least squares (2SLS) regression analysis using an instrumental variable based on the DID specifications, additional to the control variables including the year dummies and prefecture dummies.

The first instrument is using the firm's engagement in the package software business. The policy change should only affect the firms engaging in package software since the reform expand the scope of patent protection to the programs recorded in storages. Making the dummy variable taking the value one if the firm produces package software and takes zero otherwise ("package software dummy"), we introduce the interaction term between package software dummy and the policy change dummy as an instrumental variable. Although our estimation period only covers between1996 and 2003 where we have just one year before the policy change, such limitation does not necessarily cause a specification error nor a sampling bias.

As the second instrumental variable, we use an exogeneous variation of the number of patent attorneys at prefecture level that is a proxy variable of accessibility to attorneys. The firms can consult an attorney easier and the cost for access to an attorney can be lower when the attorney office is located closer, which would increase the probability of filing patent applications.[8] However, the geographical closeness to the attorney office would not directly affect the firm's growth. Since in the software industry most of the firms do not have much experience to file a software patent (Figure 1), the importance of the accessibility to patent attorney can be more significant than other technology sector, especially for the medium and small sized firms that have relatively less internal resources for patenting activity.

Distribution of patent attorneys among prefectures in Japan is highly skewed. In Japan, patent attorney is a nationally accredited, and The *Japan Patent Office Annual Report* provides an information on the number of patent attorneys at prefecture lever every year since 1999.[9] According to the report, 63.2% of the attorneys concentrates in Tokyo in 2003 (the number of internal attorneys is 3484 in Tokyo), while some prefecture has only one attorney. Table 4 shows the distribution of the patent attorneys and the sample firms by prefecture in 2003. The HHI for distribution of patent attorneys (0.43 in 2003) is higher than that for distribution of software companies (0.12 in 2003).

Note that as the internal attorney usually works only for their employer we had better remove the number of internal attorneys from the total number of attorneys to measure the prefecture-level accessibility of individual attorneys. Japan Patent Office conducts an official survey, *Survey of Intellectual Property-Related Activities* (SIPRA), that collect information on the number of internal attorneys employed by each target company. Using the average number of internal attorneys at prefecture level published by JPO, we can calculate the ratio of the independent attorneys to all attorneys by prefecture. In our estimation, we introduce the interaction term between this calculated number of individual attorneys and the policy change dummy as an instrumental variable, with using the prefecture dummies.[10]

[Table 4]

[8] While a firm can apply for a patent without a patent attorney, more than 90% of patent applications are filed by patent attorneys in Japan.
[9] We supplement the number of internal attorneys before 1998 by the number in 1999, since the survey starts collecting that information since 1999.
[10] The estimation results are robust even when we use the number of total attorneys.

Last instrument for the identification is an experience of filing a non-software patent, employed in Cockburn and MacGarvie (2011). They use this instrument to estimate the impact of filing software patent on market entry. Large part of software patents is obtained by firms in other industries (Mann and Sager; 2007, Bessen and Hunt; 2007). Their costs for obtaining software patents may be relatively low because of the economies of scale. Therefore, the experience of filing a patent would increase the probability of filing a newly accepted software patent, while acquiring a non-software patent should have less correlation with the sales growth for software business. We use the interaction term between the dummy variable capturing the past experience of filing a non-software patent and the policy change dummy.

The estimation model of the second stage is represented by equation (1) with dependent variable Y_{it} measuring the firm growth and R&D activity. The second stage estimation analyzes the effects of the program patent application ($ProgPat_{it}$) on the firm growth. The first stage estimation identifies the determinants of the number of applications of program patents, formulated by Equation (2).

$$Y_{it} = \beta_0 + \beta_1 ProgPat_{i\ t-1} + X_{it-1}^{'}\boldsymbol{\gamma} + Year_t + Prefecture_t + \varepsilon_{it} \ , \qquad (1)$$

$$\begin{aligned} ProgPat_{it} = \alpha_0 + \ & \alpha_1 Package\_soft\_firm_{it} * Policy\ \ reform_t \\ & + \alpha_3 Num\_attorney_{it} * Policy\ \ reform_t \\ & + \alpha_4 Pat\_Experience_i * Policy\ \ reform_t \\ & + Z'_{it}\boldsymbol{\eta} + Year_t + Prefecture_t + \epsilon_{i,t} \ . \qquad (2) \end{aligned}$$

In Equations (1) and (2), *i* denotes a firm and *t* denotes application year. Vectors $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\eta}$ are coefficient parameters.

The dependent variables of the second stage estimation (Y_{it}) are growth rate of sales and employees in software service. The sales in our data source (CRISF) is categorized into customized software, packaged software, online service and offline service. Moreover, to focus on the impact on the R&D activity, we use growth rate of system engineers (SEs) and programmers as a dependent variable since CRISF does not have R&D expenses. While SEs and programmers engage in various kinds of tasks, they are important inputs of R&D.

Our main independent variable is the number of program patent applications ($ProgPat_{it}$). It is after policy change in 1997 that the program patent became a subject matter of patent protection. Therefore, this variable can be a good measure to examine the impact of expanding the scope of patent protection the firm growth. For the identification of causal effect, we instrument the $ProgPat_{it}$ in the first stage estimation formulated by Equation (2).

The dependent variable of the first stage estimation is the number of program patent applications ($ProgPat_{it}$), which focuses on the firms that began to file program patents after the revision of Examination Guidelines in 1997. We also use the number of software patent applications as dependent variable which includes not only program patents but also other software-related patents. Both dependent variables would be affected by the policy reform in 1997, though the impact on the latter variable might be mitigated. We take a logarithm of both variables when they have positive values since the number of patent application is highly skewed.

The variable $Pakage\_soft\_firm_{it}$ is the dummy variable for the firms producing packaged software which would be more affected by the policy change. For our first instrument, we include the cross term with the policy change dummy $Pakage\_soft\_firm_{it} * Policy\ reform_t$. Second instrument is cross term of the $Policy\ reform_t$ and the number of patent attorneys located in the same prefecture with the focal firm (denoted by $Num\_attorney_{it}$). The third one is the cross term of the $Policy\ reform_t$ and the previous experience of patent applications for non-software inventions ($Pat\_Experience_i$).

To control for the economy of scale due to the business diversification, we include the dummy variable taking the value one if the firms operate only in the software section, that takes zero if the firm has positive sales from other business sections. About 80 percent of our sample firms (listed in the CRISF survey) are pure software firms. We also introduce the dummy variable that capture whether the firm has a parent company to control for the influence from their parent company. When a parent company is the main customer of the child firms, the sales and employees of child firm may have less correlations with their own patenting activity. As control variables, we include firm age and year dummies. We also introduce the prefecture dummies to control for the difference in the development of the prefecture. Moreover, since the growth rate of each business category can be different even within the software industry, we use the industry-level average of sales for the packaged software and customized software. The descriptive statistics of all variables is in Table 5.

[Table 5]

5. Results

5.1 Determinants of filing program patents

Table 6 shows the results of determinant of filing program patent applications, which is the first stage regression of 2SLS estimations. We use the number of program patent applications and the number of all software-related patent applications as dependent variables. We find that the coefficients of the cross term $Pakage\_soft\_firm_{it} * Policy\ reform_t$ are positive and statistically significant in all models. This result suggests that the firms selling packaged software began to apply program patents more than other firms, which also indicates that the impact of the policy change is more significant for the package software firms.

The instrumental variable, $Num\_attorney_{it} * Policy\ \ reform_t$, has also significant positive effects in all estimation models. Therefore, the geographical closeness to patent attorney can contribute to patenting activity of the firms. This result is consistent with our prediction that the firm's propensity to patent increases when the firm can access to a reliable patent attorney easier especially in the field of new patentable matter. We also find that the coefficients of another instrumental variable, $Pat\_Experience_i * Policy\ \ reform_t$, are positive and statistically significant. The firm with an experience of filing non-software patents has higher propensity to file a newly accepted program patents, which suggests the existence of the economy of scope for the patenting activity.

[Table 6]

Moreover, Table 7 shows the estimation results when we divide the sample into three groups in terms of the number of employees: the large firms (more than 300 employees), SMEs (less than 300 employees) and small firms (less than 100 employees). We see that, for the decision on filing program patents, the cross term with the package software firm and with the experience of past non-software patent applications have statistically significant effect for all subsamples: large firms, SMEs and small firms. Therefore, all types of firms start filing program patents after the subject matter was expanded especially when they engage in the business of package software and have an experience of filing non-software patents. Interestingly, the number of attorneys at prefecture level have positive effect only for the small firms. This result suggests that easier access to patent attorney have more significant effect for SMEs (especially for small firms), which indicates the importance of support by attorneys for smaller firms to acquire a patent while large firms usually employ internal attorneys.

The previous studies reveal that larger firms have higher propensity to patent due to strategic reasons to go through patent thicket in software industry (Hall and MacGarvie 2007; Cockburn and MacGravie 2011), which is consistent with our results. At the same time, our results show that smaller packaged software firms immediately respond to policy change and began to file program patents.

[Table 7]

5.2 Effects of program patent on firm growth

Table 8 shows the estimation results of the equation (1) when we use the growth rate of sales and employees in software service and growth rate of SEs and programmers. We employ the 2SLS estimation with instrumental variables (the result of first stage estimation is provided in Table 6 for all sample, and are provided in Table 7 (1), (5) and (9) for the large firms, SMEs and small firms, respectively).

The results of 2SLS estimation for the full sample show that filing program patents has positive effects on growth rate of sales, though it has insignificant effect on the employment growth and the SEs and Programmers. Combining the results of the first stage estimation, this result suggests that expanding the scope of patent protection in software industry increases the firms' patenting propensity which increases the appropriability and can result in the sales growth. Increasing employment growth and R&D growth might take more time since the firm begin to file a patent.

Dividing the sample in terms of firm size can give more clear understanding. We see that the coefficients of program patents are statistically significant for the smaller sized firms, even on the Employment growth and SE and Programmer growth. That is, the impact of filing program patents on the firm's performance growth is more significant for the SMEs. This result is consistent with the results in Lerner and Zhu (2007). However, program patent application has insignificant effect for the large firms, though policy change does promote their patenting activity (see Table 7). These results can suggest that for the large firms expanding the scope of patent protection does not increase appropriability since they had already protected their invention and business domain by "conventional" software patents even before the policy change. Therefore, the policy reform just changed the technology field where the large firm file patents or just increased the number of patent applications which expands the patent portfolio and can exacerbate the patent thicket problem. However, for the small packaged software firms that could not protect their invention, the policy change contributes to protect their invention and improve appropriability which can increase firm growth.

[Table 8]

Lastly, Table 9 examines the most significant driving factor among the three instruments, including the instrumental variable separately. We see in the second stage estimation results that the coefficients of the filing program patents are significant for the model (3) and (4). This result indicates that in total, the accessibility to the patent attorney contributes the most to the increase in the firm's performance, mainly through the effect on the smaller firms. Table 9 also provide the result of OLS estimation where we can find insignificant effect of program patents.

[Table 9]

6. Conclusion

This study empirically identifies the causal effects of the broadening of the scope of software patent in Japan. For our identification, focusing on the approval of program patent (revision of the Examination Guidelines) in 1997, we employ three instruments based on the Difference in Differences: engagement in the business domain of packaged software, the number of patent attorneys at prefecture level and the previous experience of non-software patent applications.

Our estimation results show that the policy change increased the propensity to file newly accepted program patents for smaller firms as well as the large firms. However, the effect of filing program patent on the firm growth and R&D activity are statistically significant only for the smaller firms. These results suggest that large firms that had protected their invention by hardware-related patents before the policy change just expanded their patent portfolio due to the policy reform, which have little effect on the appropriability. On the other hand, for the SMEs with little complementary asset and patent portfolio, the policy reform gave a new opportunity to protect their program-related inventions. Therefore, expanding the scope of patent protection can decrease the large firms' cost for the direct protection of subject matter, while it can increase the smaller firms' cost for entering the patenting activity as well as can improve their appropriability.

Therefore, pro-patent policy in software industry can contribute to innovation performance especially for smaller firms. Our results also show that the number of patent attorneys in the same prefecture has significant effect only for the small firms and that accessibility to the attorney after the policy reform is the main driving factor of the firm's performance. These results can derive a policy implication that supporting SMEs' patenting activity should contribute for innovation by reducing their cost and increasing their growth in the Japanese software industry.

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Table 1 History of Software Protection in Japan

Year	Content
1993 (Revision of examination criteria)	Computer program became patentable as long as hardware resource was used
1997 (Revision of the Guidelines)	Computer program recorded on storage media became patentable
2000 (Revision of examination criteria)	Computer program itself became patentable
2002 (Amendment of Patent Act)	Computer program was stated as an invention of "product"

Table 2: Sales by Business Category

	Our sample in CRISF in 2003 (1705 firms)		Survey of Selected Service Industry in 2003(7380 firms)	
	Sales (million yen)	Share	Sales (million yen)	Share
Customized Software	4,792,472	43.1%	6,637,179	46.8%
Packaged Software	1,566,021	14.1%	1,444,426	10.2%
Information Processing	119,457	1.1%	2,470,928	17.4%
System Management and Operation Contracting	873,354	7.9%	1,730,291	12.2%
Database Services	72,004	0.6%	311,779	2.2%
Other	3,685,458	33.2%	1,576,030	11.1%
Total	11,108,766	100.0%	14,170,633	100.0%

Figure 1: Share of the firms filing at least one software patent application

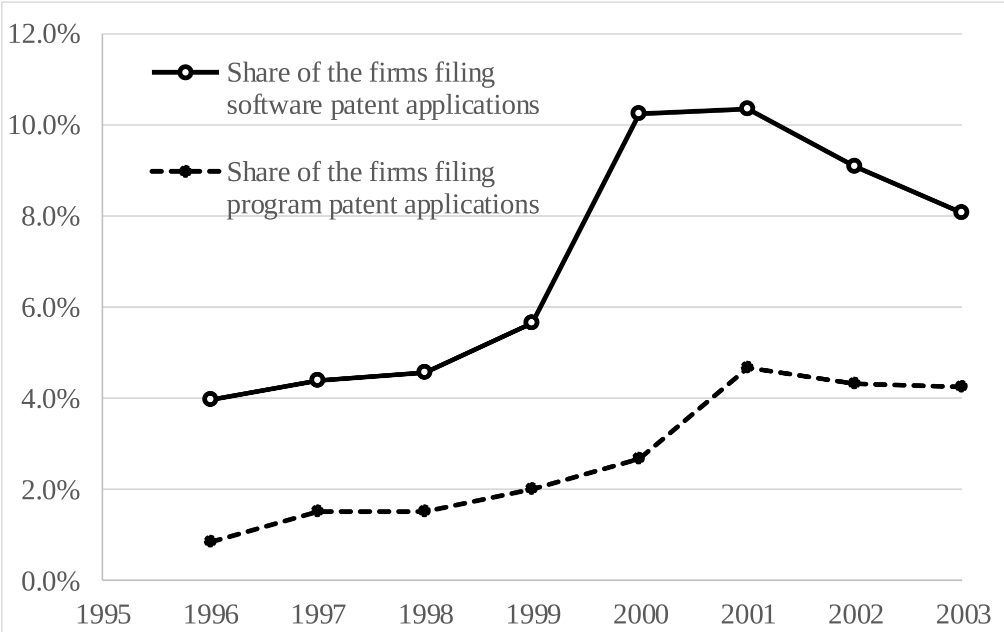

Table 3. Growth ratio and the experience of filing program patent applications

	Large firm (employee>=300)		SMEs (employee<300)	
	Program patent application		Program patent application	
	Yes	No	Yes	No
Sales growth	0.038	0.160	0.271	0.067
Employment growth	0.004	0.058	0.059	0.034
SE and Programmer growth	0.016	0.061	0.027	0.040

Table 4. Distribution of patent attorneys and sample firms by prefecture (in 2003)

Prefecture	Num. of patent attorneys	Num. of sample firms	Prefecture	Num. of patent attorneys	Num. of sample firms
1 Hokkaido	12	71	25 Shiga	72	14
2 Aomori	2	15	26 Kyoto	861	95
3 Iwate	1	13	27 Osaka	83	15
4 Miyagi	4	41	28 Hyogo	1	6
5 Akita	2	14	29 Nara	3	8
6 Yamagata	4	23	30 Wakayama	2	10
7 Fukushima	3	24	31 Tottori	13	22
8 Ibaraki	40	9	32 Shimane	12	37
9 Tochigi	7	5	33 Okayama	2	15
10 Gumma	11	18	34 Hiroshima	3	9
11 Saitama	76	8	35 Yamaguchi	3	16
12 Chiba	80	20	36 Tokushima	4	13
13 Tokyo	3484	379	37 Kagawa	2	11
14 Kanagawa	322	59	38 Ehime	35	49
15 Niigata	5	13	39 Kochi	1	3
16 Toyama	5	12	40 Fukuoka	1	10
17 Ishikawa	6	17	41 Saga	4	9
18 Fukui	5	6	42 Nagasaki	1	8
19 Yamanashi	4	6	43 Kumamoto	1	5
20 Nagano	20	9	44 Oita	1	9
21 Gifu	28	13	45 Miyazaki	4	10
22 Shizuoka	33	16	46 Kagoshima	2	11
23 Aichi	237	53	47 Okinawa	2	20
24 Mie	5	10	Total	5505	1228

Table 5: Descriptive statistics (in 1997)

	Obs	Mean	Std. Dev.	Min	Max
Program patents	1,345	0.102	2.107	0	74
Software patents	1,345	0.425	4.569	0	107
Sales growth ratio	1,345	0.110	0.664	-1.00	11.41
Employment growth ratio	1,343	0.067	0.231	-1.00	3.42
SE and Programmer growth ratio	1,294	0.075	0.248	-1.00	4.00
Number of attorneys	1,345	852.6	1225.4	0	2814
Pat experience	1,345	0.416	5.374	0	173
Pakage soft firm	1,345	0.390	0.488	0	1
Age	1,345	19.182	10.029	2	81
Software firm dummy	1,345	0.861	0.240	0.001	1
Subsidiary dummy	1,345	0.412	0.492	0	1
Average package sales	1,345	266.8	0.000	266.8	266.8
Average custom sales	1,345	1595.1	0.000	1595.1	1595.1
*Package_soft_firm*Policy reform*	1,345	0.390	0.488	0	1
*Num_attorney*Policy reform*	1345	852.6	1225.4	0	2814
*Pat_experience*Policy reform*	1345	0.416	5.374	0	173

Table 6: Determinants of application for program and software patents (First stage)

	Program patents				Software patents			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*Package_soft_firm*Policy reform*	0.050***	0.052***			0.102***	0.107***		
	(8.031)	(8.258)			(9.727)	(9.830)		
*Num_attorney*Policy reform*	0.022***		0.025***		0.028***		0.035***	
	(3.864)		(4.244)		(2.901)		(3.414)	
*Pat_experience*Policy reform*	0.001***			0.001***	0.004***			0.004***
	(15.159)			(15.275)	(26.275)			(26.323)
ln(Age)	0.023***	0.026***	0.026***	0.022***	0.041***	0.052***	0.052***	0.039***
	(4.663)	(5.397)	(5.356)	(4.483)	(5.019)	(6.234)	(6.146)	(4.827)
Software firm dummy	0.002	-0.013	-0.008	0.006	-0.106***	-0.149***	-0.140***	-0.098***
	(0.154)	(-1.034)	(-0.659)	(0.484)	(-5.104)	(-6.914)	(-6.453)	(-4.673)
Subsideary dummy	0.034***	0.034***	0.030***	0.029***	0.086***	0.088***	0.079***	0.077***
	(5.760)	(5.801)	(5.076)	(4.977)	(8.782)	(8.681)	(7.789)	(7.840)
Average package sales	-0.000***	-0.000***	-0.000**	-0.000**	0.000	0.000	0.000	0.000
	(-2.763)	(-2.861)	(-2.562)	(-2.229)	(1.019)	(0.653)	(1.047)	(1.599)
Average custom sales	0.000	0.000***	0.000***	0.000***	-0.000	0.000	0.000	0.000**
	(1.003)	(3.276)	(2.618)	(4.572)	(-0.781)	(1.142)	(1.302)	(2.439)
Constant	-0.058**	-0.104***	-0.089***	-0.134***	-0.009	-0.071	-0.072	-0.129***
	(-2.017)	(-3.880)	(-3.052)	(-5.081)	(-0.182)	(-1.549)	(-1.435)	(-2.913)
Year	yes	yes	yes	yes	yes	yes	yes	yes
Prefecture	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8,978	8,981	8,978	8,981	8,978	8,981	8,978	8,981
R-squared	0.065	0.039	0.034	0.057	0.136	0.068	0.059	0.126
F-test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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

Table 7: Determinants of application for program patents by firm size (First stage)

Dep. var.: Program patents	Large (emp>=300)				SMEs (emp<300)				Small (emp<100)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
*Package_soft_firm*Policy reform*	0.143***	0.145***			0.012***	0.013***			0.005***	0.007***		
	(4.932)	(4.985)			(5.391)	(5.245)			(3.082)	(3.281)		
*Num_attorney*Policy reform*	0.028		0.032		0.004*		0.005**		0.004**		0.005**	
	(1.111)		(1.282)		(1.699)		(2.127)		(2.153)		(2.247)	
*Pat_experience*Policy reform*	0.001***			0.001***	0.003***			0.003***	0.003***			0.003***
	(4.300)			(4.318)	(42.404)			(42.165)	(56.292)			(56.335)
ln(Age)	0.037	0.046*	0.047*	0.038	0.002	0.006***	0.006***	0.002	0.001	0.005***	0.004***	0.000
	(1.513)	(1.863)	(1.904)	(1.553)	(1.202)	(3.155)	(2.958)	(0.839)	(0.583)	(2.879)	(2.702)	(0.288)
Software firm dummy	0.044	0.015	0.023	0.052	0.004	0.003	0.005	0.005	0.002	0.004	0.004	0.002
	(0.846)	(0.295)	(0.435)	(1.001)	(0.929)	(0.617)	(0.875)	(1.140)	(0.512)	(0.861)	(0.990)	(0.667)
Subsideary dummy	0.064**	0.065**	0.058**	0.053*	0.004**	0.004*	0.003	0.003	-0.000	-0.001	-0.002	-0.001
	(2.244)	(2.285)	(2.029)	(1.875)	(2.132)	(1.781)	(1.144)	(1.473)	(-0.161)	(-0.455)	(-0.906)	(-0.527)
Average package sales	-0.000**	-0.000**	-0.000**	-0.000*	-0.000**	-0.000*	-0.000*	-0.000*	-0.000	-0.000	-0.000	-0.000
	(-2.386)	(-2.503)	(-2.121)	(-1.896)	(-2.224)	(-1.832)	(-1.685)	(-1.934)	(-0.228)	(-0.050)	(-0.014)	(-0.047)
Average custom sales	0.000*	0.000***	0.000***	0.000***	0.000	0.000*	0.000*	0.000***	-0.000	0.000	-0.000	0.000
	(1.923)	(3.516)	(2.893)	(4.365)	(1.308)	(1.887)	(1.884)	(3.231)	(-0.280)	(0.104)	(-0.082)	(1.128)
Constant	-0.234	-0.340**	-0.352*	-0.440***	-0.011	-0.027***	-0.026**	-0.023**	-0.002	-0.017**	-0.014	-0.010
	(-1.295)	(-2.087)	(-1.935)	(-2.722)	(-1.080)	(-2.633)	(-2.339)	(-2.482)	(-0.326)	(-2.075)	(-1.566)	(-1.483)
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Prefecture	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,743	1,743	1,743	1,743	7,235	7,155	7,152	7,155	5,039	5,041	5,039	5,041
R-squared	0.143	0.133	0.121	0.130	0.215	0.018	0.014	0.211	0.398	0.013	0.012	0.396
F-test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.144	0.285	0.000

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

Table 8: The impact of filing program patents on firm performance (Second stage)

	Sales growth				Employee growth				SE and Programmer growth			
	All	large (emp>=300)	medium (emp<300)	small (emp<100)	All	large (emp>=300)	medium (emp<300)	small (emp<100)	All	large (emp>=300)	medium (emp<300)	small (emp<100)
Program patents	0.600***	0.303	0.114**	0.137***	0.018	0.003	0.083***	0.075***	0.001	-0.006	0.119	0.043**
	(2.703)	(0.752)	(2.103)	(3.075)	(0.280)	(0.024)	(4.892)	(3.015)	(0.037)	(-0.092)	(1.118)	(2.234)
ln(Age)	-0.109***	-0.011	-0.124***	-0.139***	-0.034***	-0.034	-0.041***	-0.040***	-0.020***	-0.007	-0.029***	-0.037***
	(-5.464)	(-0.161)	(-3.951)	(-3.678)	(-6.440)	(-1.610)	(-7.025)	(-6.284)	(-3.805)	(-0.525)	(-4.980)	(-5.184)
Software firm dummy	-0.489***	-0.715***	-0.387***	-0.380**	-0.032	-0.145	0.012	-0.001	0.009	0.001	0.012	0.006
	(-9.967)	(-5.124)	(-3.189)	(-2.460)	(-0.775)	(-0.978)	(0.828)	(-0.064)	(0.391)	(0.016)	(0.801)	(0.302)
Subsideary dummy	-0.006	-0.111	0.034	0.026	-0.007	-0.007	-0.010	-0.016**	-0.002	-0.002	-0.006	-0.006
	(-0.270)	(-1.393)	(1.524)	(0.985)	(-0.973)	(-0.217)	(-1.520)	(-2.391)	(-0.285)	(-0.111)	(-0.946)	(-0.822)
Average package sales	0.000*	-0.000	0.000***	0.000**	0.000	0.000	0.000	-0.000	0.000*	0.000*	0.000	-0.000
	(1.927)	(-0.240)	(2.626)	(2.282)	(1.377)	(1.231)	(0.394)	(-0.930)	(1.833)	(1.700)	(0.518)	(-0.466)
Average custom sales	-0.000	0.000	-0.000***	-0.000***	-0.000***	-0.000	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(-1.558)	(0.134)	(-3.825)	(-3.280)	(-5.221)	(-1.609)	(-5.071)	(-3.305)	(-7.151)	(-3.463)	(-5.879)	(-4.299)
Constant	0.806***	0.816*	0.733***	0.748***	0.231***	0.238	0.230***	0.226***	0.189***	0.112	0.218***	0.234***
	(7.456)	(1.736)	(5.291)	(4.768)	(5.911)	(1.480)	(6.362)	(5.581)	(6.201)	(1.254)	(6.947)	(6.189)
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Prefecture	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8,978	1,743	7,235	5,039	9,077	1,769	7,301	5,077	8,769	1,724	7,038	4,855
R-squared		0.068	0.020	0.023	0.007	0.010	0.019	0.024	0.014	0.019	0.020	0.028
F-test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Robust t-statistics in parentheses

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

Note1: The result of the first stage estimation is provided in Table 6 (1) for all sample.

Note2: The results of the first stage estimation are provided in Table 7 (1), (5) and (9) for the large firms, SMEs and small firms, respectively.

Table 9: Driving factor of the firm performance

	2nd stage: Sales growth				1st stage: Program patents				OLS
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(5)
Program patents	0.600***	0.509	2.836**	0.465*					0.036
	(2.703)	(1.082)	(2.531)	(1.817)					(0.750)
*Package_soft_firm*Policy reform*					0.050***	0.052***			
					(8.031)	(8.258)			
*Num_attorney*Policy reform*					0.022***		0.025***		
					(3.864)		(4.244)		
*Pat_experience*Policy reform*					0.001***			0.001***	
					(15.159)			(15.275)	
ln(Age)	-0.109***	-0.106***	-0.167***	-0.105***	0.023***	0.026***	0.026***	0.022***	-0.094***
	(-5.464)	(-4.712)	(-4.474)	(-5.237)	(4.663)	(5.397)	(5.356)	(4.483)	(-3.435)
Software firm dummy	-0.489***	-0.489***	-0.469***	-0.490***	0.002	-0.013	-0.008	0.006	-0.493***
	(-9.967)	(-9.989)	(-7.724)	(-10.034)	(0.154)	(-1.034)	(-0.659)	(0.484)	(-3.808)
Subsideary dummy	-0.006	-0.004	-0.073*	-0.002	0.034***	0.034***	0.030***	0.029***	0.010
	(-0.270)	(-0.138)	(-1.674)	(-0.100)	(5.760)	(5.801)	(5.076)	(4.977)	(0.455)
Average package sales	0.000*	0.000*	0.000**	0.000*	-0.000***	-0.000***	-0.000**	-0.000**	0.000
	(1.927)	(1.817)	(2.371)	(1.847)	(-2.763)	(-2.861)	(-2.562)	(-2.229)	(1.380)
Average custom sales	-0.000	-0.000	-0.000**	-0.000	0.000	0.000***	0.000***	0.000***	-0.000
	(-1.558)	(-1.291)	(-2.376)	(-1.381)	(1.003)	(3.276)	(2.618)	(4.572)	(-0.799)
Constant	0.806***	0.793***	1.114***	0.787***	-0.058**	-0.104***	-0.089***	-0.134***	0.728***
	(7.456)	(6.505)	(5.574)	(7.218)	(-2.017)	(-3.880)	(-3.052)	(-5.081)	(5.874)
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Prefecture	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8,978	8,981	8,978	8,981	8,978	8,981	8,978	8,981	8,981
F-test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.94e-09

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