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Intellectual Property Rights for Software and Accessibility to Venture Capitalists

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Abstract
Although computer software has been protected by both patent rights and copyrights, the mixed effects of these two intellectual property rights have not been relatively explored. In this study, we examine the signaling value of patenting and copyright protection in software technology on receiving venture capital (VC) financing using notable Japanese software SMEs data. We find that both obtaining software patents and copyright registrations accelerate the VC financing for smaller firms. We also find that possessing both intellectual property rights have a significantly negative impact on the finance of VC. The results show that software patents and copyright registrations are largely substitutes in terms of signaling.

Keywords**:** Software patent, Software copyright, Venture capital, Signaling effect
JEL code**:** O34, G24, M13

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1. Introduction

Computer software has been protected as copyright since 1980s, and this has been also protected by patent right since 1990s in many advanced countries. Thus, software is protected as two different types of intellectual property rights. However, mixed effect of these two rights on market efficiency has not been relatively explored. In this study, we examine the signaling value of patenting and copyright protection in software technology on receiving of venture capital (VC) financing using notable Japanese software SMEs data. Despite some studies have focused on the impact of software patent on signaling effect as well as economic performance, mixed effect with software copyright has received little attention in previous studies. Further, the exceptional studies don't focus on signaling effect that both intellectual property rights could have on VC financing (Mann 1995; Lerner and Zhu 1997; Suh and Hwang 2010). We attempt to fill this gap.

Signaling theory is that only high quality one can send a signal to outsiders with less cost than low quality ones under asymmetric information (Spence 1973). Obtaining patents may have such a credible signal in financial market because patenting imposes burden for less technology oriented firms than innovative firms (Long 2002)[1]. Further, such burden is likely to be serious among smaller firms, which will enhance signaling value of patenting (Hottenrott et al. 2016). In this view, expansion of patent scope of computer software contributes to create efficient financial markets. However, because the similar role may be expected for software copyright registration scheme under which software developers can register their original computer programs to verify their originality[2]. Therefore, given existence of software copyright registration, in order to evaluate the impact of software patent on financial market as a signal, it should be crucial empirical issue whether software patent had additional economic impact in software industry.

To obtaining patent rights, inventors need to fill patentability conditions whether their inventions satisfy novelty and inventive step. Further, inventors have to pay some costs to register and maintain their patent rights. In contrast, one can register their computer programs as copyrights without any criteria with lower costs. Thus, since patenting is likely to have higher signaling effect than software copyright registration, software patent would potentially substitute software copyright after software patent was introduced. However, patent value in newly patentable technological area will be unclear because examination criteria will be vague and there is no much accumulation of judicial precedents on effective scope of right for each patent. The boom of business method patens in later 1990s was good example of this because almost all business method patents were rejected in

[1] Since a patent right assigns substantial monopoly power for inventive firms, patent may not match the definition of "signaling value," which itself generally is assumed not to have any value. Therefore, in this study, we use signal as broader meaning. applications

[2] This scheme has been introduced in several countries such as Japan, US and Korea.

patent examination process[3]. As a result, signaling value of software patents may be not always to overwhelm the signaling value of software copyright registrations, at least, at the beginning of introducing newly patentable areas. In this meaning, software patents may complement software copyright registration.

To access the signaling effect of software patent and copyright registration on VC financing, we use a notable database for software companies in Japan in 1996-2003 published by Ministry of Economic, Trade and Industry. This database contains detail information of Japanese software firms such as name, address, founding year, name of stock holders and each sales of software product line. Next, we matched this database to patents provide by Institute of Intellectual Property (IIP) and computer programs registered as copyright in *Software Information Center* (SOFTIC).

With these matched data, we use smaller firms which have less than 100 employees because they often face strict financial constraints and information asymmetry in the financial markets will be more serious. Further, we only focus on the first round of VC financing because investors are likely to face more serious information asymmetry than later round, and role of intellectual property rights will be more important. Using the first round also has another advantage that it will mitigate causality of firms patenting and VC financing compared to the latter round of equity finance (Conti et al. 2013), though we employ instrumental variable method to valid the causality between them.

Further, focusing on the Japanese software companies has some advantages to understanding the effectiveness of software patents and copyrights. First, since Japan had policy reforms on software patent rights in our estimation period, this seems to be precious opportunity to investigate the impact of software patent on economy as a quasi-natural experiment. Second, since Japan introduced copyright registration system in 1988, we can count the number of software copyrights. While the number of registered software copyrights are only small part of all software, this is even notable opportunity to understand the meaning of software copyrights. Third, while patentability for software patents is different across countries and this may bring to different economic result, almost all studies focus on US. Useche (2014), which is one of few exceptional studies comparing US with EU software patent rights, find that software patents in EU have stronger signaling value than those in US because examiners in European patent office are in general, less applicant friendly than those in US patent office. Thus, investigating software patent in Japan may shed right the different aspect of intellectual property rights.

Our findings show that, given the copyright protection for software, software patenting still accelerate receiving first round of VC financing among smaller software companies. We also find that the companies which use software copyright registration receive venture financing faster.

[3] Japan Patent Office webpage (https://www.jpo.go.jp/seido/bijinesu/biz_pat.htm)

However, possessing both software patent and copyright registration have significantly negative impact on finance of VC. Further, the signaling value of software copyright registration on VC financing has been decreasing in 2000s. These results show that software patent and software copyright registration are largely substitute in terms of signaling, and software copyright registration gradually has been substituted by software patents. This presents that partly explains the downward trend of the number of software copyright registrations in Japan. In the policy perspective, however, the appearance of broader scope of software patents would not have stronger impact in financial market because software patent just replaced software copyright registration.

The rest of this paper proceed as follows. We explain intellectual property rights for software in Japan in next section, and then we review existing literature in section 3. We next explain our data and empirical strategy in section 4. We then present our results in section 5. We conclude our results.

2. Intellectual Property Rights for Software in Japan

In Japan, protection of computer program started in the Copyright Act amendment from 1985. In this law, definition of the computer program was an expression of a combination of instructions to cause a computer to function in order to be able to obtain a certain result. After all, computer program has been protected as source codes as expression, and this mean that the law didn't protect any ideas included in source code. Therefore, one was easily able to imitate the original programs only if he/she could write down codes with different impression. Thus, this is limited means to deter entry of competitive software developers.

The 1985 copyright act amendment additionally implemented software copyright registration scheme that original developers could register their computer programs in order to enhance legal enforcement in a legal dispute. The main function of this registration scheme is to confirm original date of development of the programs. This would be useful function because in general it is very difficult to show when the programs were developed. Alternative function of the scheme is to make to transfer the programs easily through confirming the bulk of the program. Software developers can register their programs without any examination process, and the cost is only seventy thousand yen per program when they register it. They don't need to disclose source codes. This scheme has put into practice in 1987 by the SOFTIC. Figure 1 shows the transition of software copyright registrations. One can observe that the number of registration has been decreasing since around 2000.

Scope of computer software patents was gradually expanded. 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[4]. As development of software technology in 1970s, programs patentable under the Microcomputer Patent Guidelines announced in 1982 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". After that, 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 resource(s), as utilizing the laws of nature. That is, computer programs could be patented only when it was embedded in hardware. Nevertheless, this revision eliminated "storage medium with program recorded" from among the patentable subject matters. 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, even if rival firms sold similar software which was patented by a firm in the form of CD-ROM, the firms would not have sued by the patent holder. That is, while hardware companies with software section such as electronics companies in manufacture sector could easily patent their software inventions, it was difficult for software companies in software industry to register their invented software as patents.

This obstacle for software companies was solved in the revised Guidelines released in 1997; "storage medium with program recorded" became describable in the claims as an invention of "product." Software firms could patent their computer programs without any relationship of hardware. This reform would affect in particular, package software companies because their products were not protected as patents without it. Further, the examination criteria were again revised in 2000, recognizing the program itself as the subject of protection in accordance with the advancement of information communications technologies on Internet. Finally, the amendment of the Patent Act in 2002 specified that a computer program itself is to be treated as a "product," which means that all computer programs that are satisfied with "invention" are patentable technology while this amend only built in a change that had been put into practice.

3. Literature Background

3.1 The impact of expansion of software patents on software industry

Patent right gives a company monopoly power for their own technology. One expects that expansion of patent scope may lead to an increase profitability among innovative firms. While some studies

[4] Patent act in Japan requires utilize the law of nature with patentable technology.

have focused on this issue, the empirical evidence for the impact of the implementation of software patent on firm performance has been mixed. Lerner and Zhu (2007) observed the Lotus v. Borland ruling, which resulted in a relative strengthening of patent rights, and analyzed its effect on application behaviors and corporate performance among software companies. The authors indicated that increased software patent applications effectively increased sales and R&D spending among those companies. Merges (2006) shows that a positive correlation actually exists between patent acquisition and corporate performance. Wagner and Cockburn (2010) also use US publicly-traded firms to show that software companies with patents survive more than companies without it, but interestingly business method patents have little impact on their survival. Bessen and Hunt (2007) indicated that United States legal amendments related to software patents do not promote corporate research and development (R&D) activities, although they are increasing the number of patents. Motohashi (2009) find that software patenting after expansion of software patent in Japan didn't enhance firms' market value as well as TFP. Additionally, Hall and MasGarvie (2006) demonstrated that an expansion of the scope of software patents does not increase the market value of pure software companies with a small patent portfolio, although it increases the market value of hardware companies with a large patent portfolio. The authors explain that behind instances of pure software companies is a steep rise in licensing expenses for related patent rights at the time of development.

Some studies focusing on the explosion of software patent as a "thicket", patent would deter entry of new software companies. Cockburn and MasGarvie (2007) found that the number of new entrants tends to decline in technology fields with a supposed "patent thicket," in which the rights to related technologies are established in a complex manner among many companies.

There are few empirical evidences on the relationship between the protection of software patent and copyright. Lerner and Zhu (2007) focusing on the Lotus v. Borland ruling, which limited scope of software copyright protection, find that narrower software copyright protection lead to an increase the number of patent application among firm that directly affected by the court rule change. The authors conclude that this shows there is substitute relationship between software patent and copyright. For qualitative analysis, Mann (2005) examines the role of appropriablity between patent and copyright in software industry. He finds that copyright is less profitability than patent through protecting their right because a developer could easily write different literally codes having the same function once they understand the function of the idea. However, in his interview, copyright is still important to deter criminal piracy. This shows that software patent and copyright have a room to be complement each other, although both are substitutional in terms of deterring competitors. Suh and Hwang (2010) use hardware companies as well as software ones in Korea where has similar software copyright registration scheme to find that while hardware firms often rely on software patents, smaller

software firms tend to use copyright protection rather than patent, and registration of software copyrights has positive impact on both software and total revenue but patents don't have those impacts. They concluded that, given the burden of obtaining of patents and shorter product cycle of software, software copyrights would be convenient means to protect their software products for smaller firms. This view shows that software copyright protection effectively protects smaller companies' software technology compared to patent.

Thus, some previous studies focused on exploiting the appropriability of patent and copyright, no one have exploited the signaling value of both intellectual property right. We try to fill this gap.

3.2 Signaling effect to financial markets

Since SMEs often do not have sufficient cash flow, it is critical issue to involve how to smoothly raise funds externally. Some studies focus on whether patenting is as a kind of signal to potential fund providers when obtaining external funds because obtaining the rights are not only costly, but also difficult, unless the company actually possesses a certain level of technology (Long 2002).

Conti et al. (2013) use Israeli technology start-ups to show that possessing patents facilitate to access more than second round VC financing even controlling for reverse causality that VC finances ask the start-ups to get more patents. Hottenrott et al. (2016) focus on established companies rather than start-ups to examine the effect of patenting on access to financial markets under cash constraint. They find that smaller firms that face more financial constraints could continue to R&D activities through possessing patents as a signaling value. Hus and Ziedonis (2007) focus on whether filing a patent application encourages venture capitalists to invest in US semiconductor start-ups, also finds that this leads to additional investments made by venture capitalists. Haeusseler et al. (2014) study on German and UK startups in biotechnology to show that information about patent process such as search reports, opposition process and as well as patent applications have a function to decide first round of VC investment as a signal.

Focusing on signaling value of software patent, Mann and Sager (2007) use venture-backed start-up in US to find a positive relationship between venture capitalists' equity investments and software patent applications. Further, Cockburn and MasGarvie (2007) use US data to reveal that software start-up companies that have filed a patent application are more likely to have a higher IPO, while having a lower probability for bankruptcy, demonstrating the power of the patent application as a signaling function. Graham et al. (2010) compare bio-tech and software start-ups in US to find that while the former use patent aggressively, the latter tend to avoid patenting. Further they finally

find that despite patenting brings limited advantage of appropriability, they still regard to important role to gain financial supports. Useche (2014) find that software patent in EU is stronger signals to the financial markets than in US because of obtaining patents much harder in EU than in US.

Taken together, those studies show that a positive relationship between patenting and venture capitalists' investment exists. However, there is no either empirical evidence for signaling value of copyright nor mixed up effect of signaling value of patent and copyright. This will matter in software industry to evaluate the additional impact of expansion of scope of software patent.

3. Data

This study uses data for Japanese software companies listed on *The Directory of Information Processing Service Companies (DIPSC)* published by the METI. The directory publishes annual information, such as business details of software companies, in accordance with the Statute Regarding the Ledger of Information Processing Service Companies (1973) stipulated by the METI[5]. This contains capital, establishment year, sales, the number of employees, sales by the type of information processing service, the number of employees by occupation, and main stockholders' list. This study uses seven years of data from this data, covering 1996 to 2003. Although the number of responding companies varies by year by year, there are approximately 5,000 companies involved in each year.[6] In this study, we used companies with less than 100 employees, to focus on SMEs[7]. Further, we drop the first appearance year of the sample because we cannot identify when the company received VC investment. As a result, the estimation period is 1997-2003. Our sample is unbalanced panel, and our final sample contains 5807 firm-year observation with different 765 firms.

The company's obtaining of funds from venture capitalists was identified by whether venture capitalists are listed in the section for reporting shareholders in the DIPSC. Venture capitalists were identified by referring to the list of member companies of the Japan Venture Capital Association (JVCA), as well as major venture capitalists in Japan, such as the JAFCO. Patent data for these companies was collected by matching using company names in the IIP Patent Database, published by the Institute of Intellectual Property (IIP).[8] Software patents which previous studies consider is broadly categorized into two methods. One is using keywords classification (Bessen and Hunt, 2007) and the other is using technological classification such as IPC or US Patent Classification (Motohashi 2008; Mann and Sager 2007; Graham and Mowery 2003). Some studies use the combination of these

[5] The Japanese name is *Jōhōshori sābisu kigyō-tō daichō.*
[6] Please also refer to the work of Yamauchi, Onishi, and Yoneyama (2011) for more detailed data.
[7] We have estimated the same equations explained bellow using whole sample including large software firms. The results show that software patenting does not significantly accelerate VC financing.
[8] Please refer to the work of Goto A. and K. Motohashi (2007) regarding the IIP Patent Database.

two methods (Hall and MacGarvie 2006; Suzuki 2009)[9].

We employ the combination of keywords and technological classification 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. Next, we find the patents that have the keywords "recording medium", "program", "system" and "software" in the title of inventions from software patents to classify kinds of software patents.

Registered software copyrights are disclosed in the SOFTIC webpage[10]. This information only includes title of registered computer program, field and name of copyright owner. We matched the software companies name to copyright owners' name.

Table 2 presents the percentage of firms that received VC financing relative to all firms is only 3%, showing relatively small sample. This is because our dataset covers with broader defined software companies than previous studies e.g. established SMEs, subsidiaries of large electronics and telecommunication firms as well as start-ups. 15% of patenting firms finally received VC investments. This is much higher than 1.5% of non-patenting firms. Patenting firms is likely to obtain VC finance more than non-patenting firms. 28% of patenting firms also registered their program to copyright. This is also higher than non-patenting firms, showing that in general, patenting firms prefer to having copyright registration too.

4. Empirical Strategy

This study examines whether possessing software patents as well as software copyright registrations shorten the time interval to receiving VC financing in small- and medium-sized software companies. To do this, we employ cox proportional hazard model as follows,

$$\lambda(\mathrm{t}|x_1,\cdots,x_k) = \lambda_0 \mathrm{EXP}(\mathrm{X}\beta)$$

This shows that the probability of receiving VC financing increase year by year for all firms by λ_0. Further, the probability depends on the covariates $\mathrm{X} = (x_1,\cdots,x_k)$. Our covariates change firm i and year t, showing hasten or delay VC finance. Our main covariate is logarithm of stock of software patents. Almost all patents are appeared after expansion of software patent. We summation those patents with plus one to prevent zero firm-year from dropping from our sample. Further, to examine the various kind of signaling effect across patents, we also employ the logarithm of stock of

[9] Layne-Farrar (2005) examines the definition of software patent.
[10] The database is disclosed in this web page: http://www.softic.or.jp/en/index.html

non-software patents to identify the signaling effect of "software patent" from other kind of patents. We also use logarithm of stock of business method patents to observe the impact of the business method patent, as the number increases once it gains attention, as in the 1998 case of State Street Bank vs. Signature Financial Group in the United States. We employ logarithm of the stock of software copyright registrations to identify the effect of software copyright registration on VC financing.

As for other covariates, we use software package firm dummy to control for business areas within software industry. This variable is one if the firm produces software package, otherwise is zero. The company that produce software package products in the markets needs more money because economy of scale is crucial. We also employ a dummy for software specialist to identify whether the company has a non-software business. This is a variable coded one if the company specializes in software, and coded zero otherwise. Additionally, we employ logarithm of firm age as covariate to control for age effect related to firm behavior. Finally, we use logarithm of the number of software programmers to represent the company's technical capabilities.

Table 3 and Table 4 show summary statistics and correlation matrix, respectively.

5. Results

5.1 Main results

Table 5 reports that the main estimation results of the survival analysis. We show hazard ratios rather than coefficients of the estimation results, and standard error clustered by firm shown in parenthesis. The hazard ratio of the variable more than 1 presents a higher probability of receiving VC financing. Conversely, the hazard ratio less than 1 shows a decreasing rate of receiving of VC finance.

Log of stock of software patents are highly significant and its hazard ratio is 2.06, showing that 1% increase of cumulative software patents accelerate receiving VC financing by 200% in column (1). Interestingly, the stock of non-software patent is positive but insignificant, meaning that non-software patents does not affect earlier VC finance in software SMEs in column (2). Given software became new patentable technology area, software patents might be perceived to vanish information asymmetry between software companies and VCs in financial markets.

The stock of business method patents is insignificant in column (3). Business method patents seems not to have a signaling value. This result is understandable because only 8% business method patents applied in the boom of late 1990s were finally granted[11]. That is almost all business method patents that were applied in late 1990s didn't have any technological advance. This result also

[11] Japan Patent Office webpage (https://www.jpo.go.jp/seido/bijinesu/biz_pat.htm)

indicates that venture capitalists had ability to identify patent value even under IT bubble that venture capitalists actively invested start-ups in the same period. We could confirm the high screening ability of VCs in column (4), showing that the stock of the number of forward citations instead of simple patent counts, is significant and the hazard ratio is more than 1 meaning the stock of the number of forward citations accelerate VC finance.

In all estimation, the stock of copyright registrations are significant and the hazard ratios are more than 1, suggesting that 1% increase of copyright registration accelerate venture financing by approximately 180% in column (1). This shows that software copyright registration has the same signaling function as software patent. To examine whether substitute effect between patent and copyright exist or not, we insert interaction term between the stock of software patents and copyright registrations to the basic equation in column (1) in Table 6. The hazard ratio of the interest is significantly less than 1. This shows that total effect of both possessing patent and copyright is less than that of having either one. We conclude that these two intellectual property rights are substitute rather than complement in terms of signaling value. This result coincidence previous research results that found substitute relationship between two intellectual property rights (Lerner and Zhu 2007)

Further, to confirm transition of signaling effect of the both intellectual property rights on VC financing, we next add the interaction terms between the stock of both intellectual property rights and after-2000 year dummies to the basic equation, respectively. Since the 2000 is the final year of the expansion of software patent rights, as we explained above, the year should appropriate to measure the change of protection of the software patent. The results are in column (2) in Table 6. The interaction term for the stock of software copyrights is significant and the hazard ratio is 0.35, showing that the effect of software copyrights on VC financing has decreased after 2000, while the interaction term for stock of software patents and after-2000 dummy is insignificant. This shows that the role of software copyright in terms of signaling value disappeared in 2000s, while that of patent remained in the same period. In the long run, software patent has substituted software copyright registration. This explains that the number of software copyright registration has been decreasing in 2000s (Figure 1).

As for other covariates in the estimation, software package firm dummy variable is significant and more than 1 in all estimation. This presents that software package companies can receive venture finance faster than other companies. Further, the dummy variable for software specialized companies was less than 1 and statistically significant, indicating that companies with a certain number of other businesses are significantly more likely to obtain funding faster when considering equity investments by venture capitalists. This suggests that venture capitalists may prefer diversified companies to software specialized ones.

The results revealed that the logarithm of company age is statistically significant and the hazard ratio is 0.33-0.31. Younger companies are significantly more likely to obtain funds from venture capitalists faster than older companies. The number of programmers was statistically insignificant, although the hazard ratio is more than 1 in all estimates, showing that venture capitalists get full information from companies' outputs such as patents or copyrights rather than inputs such as the size of software development section.

5.2 Robustness checks

When the relationship between venture capital and patent application is considered under asymmetric information, there is a simultaneous decision problem, questioning whether equity investments from venture capitalists leads to an increase in patent applications (Kortum and Lerner, 2000), or alternatively whether patent application encourages venture capital investment. The causal relationship that "patent application encourages venture capital investment" cannot be explained unless this problem is solved[12]. Further, unobserved firm's heterogeneity such as technological capability may still bring bias to our estimation results.

To address this possibility, we use two instruments in the estimation. Instruments need to fill two conditions that an instrument is correlated with patents, but the variable does not directly affect venture capital investment. While it is difficult task to find appropriate instruments, we finally decide to use the number of patent attorney in each region as an instrument[13]. In case that a company apply for a patent, the company has to contact to a patent attorney and ask him/her to write a patent document and to proceed patent application procedure. In this process, the company and the attorney need to communicate with each other frequently. Since the cost will proportionally increase with the geographical distance, a company which is far distance form patent attorney office may give up to apply for patents. Thus, geographical distance between software companies and patent attorney offices will affect their patenting behavior, especially SMEs which do not have so much cash flow. Further, since software patent became patentable area, many SMEs are likely to need stronger attorney's assistance in patenting process. The number of attorneys by region was obtained from the *Japan Patent Office Annual Report* for each year.[14] The data included patent attorneys who were employed by companies not by patent attorney offices. To handle with this, we subtracted those patent attorneys by using the Japan Patent Office official IP survey, called *Survey of Intellectual Property-Related Activities* (SIPRA) that asked the respondent companies about the number of such patent

[12] It is important to note that this causal problem may not be so serious in our estimation because we focus on first round of VC investment (Conti et al. 2013)

[13] We use 47 prefectures in Japan as regions.

[14] However, for this analysis we only used data on the number of attorneys in and after 2009. For the period prior, we retroactively applied the number of attorneys in 2009.

attorneys they employed.

However, since the number of patent attorney concentrate on the bigger city such as Tokyo, our instrument may not distinguish agglomeration effect from the "distance effect". In order to cope with this, we additionally use the average cost to file a patent by regions as the instrument. To reiterate, although the cost to file a patent would link to whether to file a patent application, this is a variable that does not directly affect venture capital investment. Additionally, as patent application fees and attorney's fees have been liberalized by the attorney's office since 2001, the costs are likely to vary somewhat after 2001 because of price competition among patent attorneys within the same region. It is also imaginable that, when costs such as travel expenses, which are not listed in the Japan Intellectual Property Association guidelines, are considered, the costs by region would vary to some extent. We used the SIPRA to calculate patent application costs by region. The surveys for 2002 and 2003 question the domestic patent application cost. Additionally, the 2003 survey questions the number of domestic patent applications. This paper used this data to calculate the average cost per patent application by region. As no data exists for the period prior to 2000, we decided to retroactively apply the amount in the years prior to 2001. It can be noted that the average cost, which was approximately 300,000 yen, is almost the same as that suggested by the questionnaire survey conducted by the JPAA on attorneys. Since both these two instruments have some defects.

Table 7 presents the result using the number of patent attorney solely in column (2), and the result using both instruments in column (4). The results of first stages in both estimations are in column (1) and (3), respectively. While the number of patent attorney is strongly significant and positive in both estimations, average patent application costs is negative but insignificant in column (3). *F* statistics without excluding instruments are 9.7 and 5.9, respectively, showing that we don't marginally concern about weak instrument. However, Hansen *J*-test for over-identifying restrictions is statistically significant, there is a doubt for the exogenous assumption for the instrument. Thus, we should see in column (2). The stock of software patents is still statistically significant and positive, showing that at least software patenting lead to an increase the probability on receiving VC financing as a signal.

6. Conclusion

This study examines that, given existence of software copyright, the additional impact of the expanded scope of software patent rights on financing of VC as signal under asymmetric information between software companies and venture capitalists. Our estimation results show that while software patenting in SMEs accelerated receiving VC financing, non-software patent did not have such a useful

effect. The same signaling effect was observed for software copyright registration, but this effect disappeared after 2000 when was the final expansion of software patent. This result shows that while software copyright registration had helped to convey information of innovative software companies to financial market, appearance of software patent gradually substituted for this function. The most reasonable explanation for the substitutional relationship between software patent and copyright would be that obtaining patents impose more burden for software companies than registration of copyrights, and this strengthen the signaling value of software patents for venture capitalists. This partly supports for the results of Lerner and Zhu (2007), showing that software patent and copyright protection is competitive in terms of firms' applications behavior. In this view, the expansion of the scope of software patent just substitute software copyright registrations in terms of signaling value, and this would not have any positive impact on financial market. While software copyright has important role to eliminate dead copy or piracy that was brought by sellers rather than competitive developers, the role of registration system such as signaling, protection of ideas may be ended in term of signaling value.

Our study remains future works. Our study doesn't mention about monopoly power of software patent and copyright registration. However, this is interest and important issue, and exploiting it is our next task. Further, our result casts another question why software companies do not obtain patents despite there is signaling value. In our dataset, only 11% of the firms applied for patents and 44% of the firms received VC financing without patenting. Answering this question is our further task. Even so, our findings still show an important step for understanding of intellectual policy for software patent and copyright.

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Figure 1 The transition of software copyright registrations

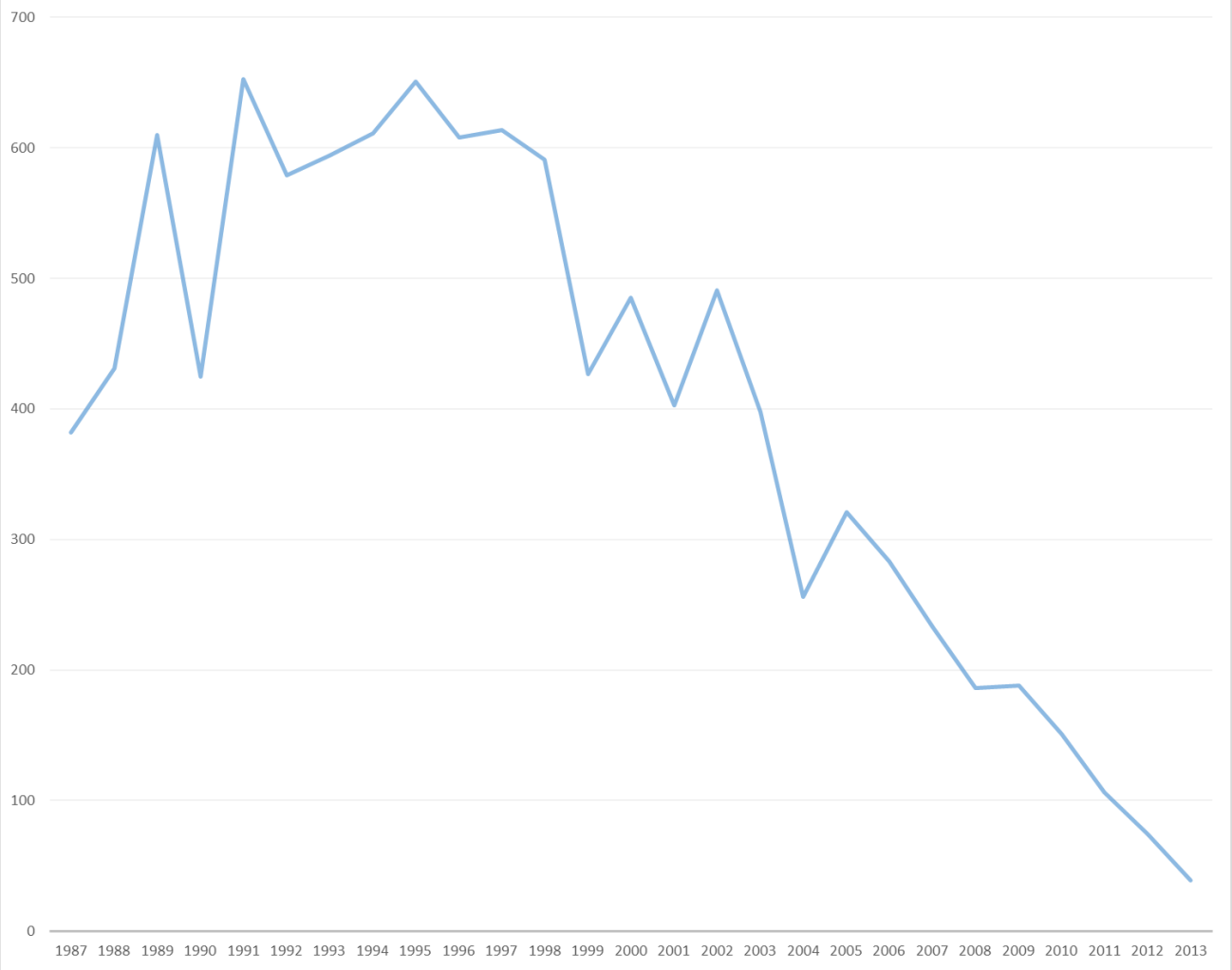

Table 1 History of Software Protection in Japan

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 Patenting, Copyright registration and VC finance

	N	Firms receiving VC financing	Firms registrating copyright
Patenting firms	212	32(15.1%)	46(21.7%)
Non-patenting firms	1705	25(1.5%)	104(6.1%)
	1917	57(3.0%)	150(7.8%)

Table 3 Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Venture capital finacing dummy	0.00	0.06	0	1.00
The stock of software patents	0.10	0.36	0	5.09
The stock of non-software patents	0.06	0.37	0	4.99
The stock of business method patents	0.03	0.20	0	4.32
The stock of software patents without businees method patents	0.07	0.31	0	4.49
The stock of forward-citation weighted software patents	0.11	0.48	0	6.09
The stock of software copyrights registrations	0.07	0.32	0	3.53
Package software firm dummy	0.38	0.48	0	1.00
Software specialization dummy	0.73	0.44	0	1.00
Age	2.72	0.58	0	4.23
N of Programmers	1.85	1.18	0	5.21
N of Patent attorneys by region	3.46	2.62	0	8.01
Average cost of patent applications by region	3.39	0.06	3.14	3.91

Table 4 Correlation matrix

Variables	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.
a. Venture capital finacing dummy	1.00												
b. The stock of software patents	0.08	1.00											
c. The stock of non-software patents	0.04	0.54	1.00										
d. The stock of business method patents	0.01	0.66	0.26	1.00									
e. The stock of software patents without businees method patents	0.09	0.92	0.57	0.36	1.00								
f. The stock of forward-citation weighted software patents	0.07	0.90	0.49	0.61	0.84	1.00							
g. The stock of software copyrights registrations	0.06	0.10	0.14	0.07	0.12	0.08	1.00						
h. Package software firm dummy	0.05	0.09	0.05	0.05	0.08	0.09	0.12	1.00					
i. Software specialization dummy	-0.02	-0.04	-0.06	-0.01	-0.03	-0.03	0.03	0.03	1.00				
j. Age	-0.05	0.06	0.07	0.02	0.05	0.05	0.09	-0.04	-0.05	1.00			
k. N of Programmers	0.00	0.05	0.00	0.03	0.06	0.04	0.06	0.03	0.16	0.13	1.00		
l. N of Patent attorneys by region	0.03	0.09	0.01	0.07	0.08	0.10	0.02	0.02	0.13	0.11	0.17	1.00	
m. Average cost of patent applications by region	0.01	-0.04	-0.02	-0.04	-0.02	-0.04	-0.01	-0.01	-0.03	-0.02	-0.05	-0.04	1.00

Table 5 Estimation results from OLS

	(1)	(2)	(3)	(4)	(5)
	Receiving VC financing				
The stock of software patents	2.462*** (0.639)				
The stock of non-software patents		1.482 (0.376)			
The stock of business method patents			1.143 (0.634)		
The stock of software patents without businees method patents				2.783*** (0.737)	
The stock of forward-citation weighted software patents					1.796*** (0.366)
The stock of software copyrights registrations	1.939*** (0.477)	2.373*** (0.618)	1.873** (0.475)	2.522*** (0.519)	1.988*** (0.487)
Package software firm dummy	4.245*** (2.186)	4.269*** (2.213)	4.201*** (2.163)	4.403*** (2.267)	4.145*** (2.142)
Software specialization dummy	0.456* (0.217)	0.488 (0.232)	0.464 (0.217)	0.478 (0.226)	0.469 (0.222)
Age	0.314*** (0.077)	0.310*** (0.076)	0.312*** (0.079)	0.321*** (0.078)	0.334*** (0.082)
N of Programmers	1.193 (0.210)	1.205 (0.245)	1.203 (0.219)	1.192 (0.231)	1.212 (0.216)
Log_likelihood	-120.602	-123.863	-120.088	-124.725	-121.601
Observations	5807	5807	5807	5807	5807

Hazard ratios are shown.

Robust Standard Errors are in parentheses.

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

Table 6 Estimation results with the interaction effects between patent and copyright

	(1)	(2)
	Receiving VC financing	
The stock of software patents	3.056*** (0.777)	3.700*** (1.506)
The stock of software copyrights registrations	2.859*** (0.751)	4.010*** (1.230)
The stock of software patents * The stock of software copyrights registrations	0.699* (0.135)	
The stock of software patents * After 2000 dummies		0.638 (0.330)
The stock of software copyrights * After 2000 dummies registrations		0.352** (0.144)
Package software firm dummy	4.238*** (2.191)	4.173*** (2.159)
Software specialization dummy	0.493 (0.229)	0.455 (0.222)
Age	0.294*** (0.068)	0.287*** (0.068)
N of Programmers	1.119 (0.196)	1.138 (0.203)
Log_likelihood	-119.779	-118.343
Observations	5807	5807

Hazard ratios are shown.

Robust Standard Errors are in parentheses.

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

Table 7 Estimation results from two stage OLS with instrumental variables

	(1)	(2)	(3)	(4)
	First stage	Receiving VC financing	*First stage*	Receiving VC financing
The stock of software patents		0.079*		0.063*
		(0.044)		(0.037)
The stock of software copyrights registrations	0.097	0.004	0.097	0.005
	(0.061)	(0.008)	(0.061)	(0.007)
Package software firm dummy	0.057***	0.000	0.056***	0.001
	(0.019)	(0.003)	(0.018)	(0.002)
Software specialization dummy	-0.051**	0.000	-0.051**	0.000
	(0.022)	(0.003)	(0.022)	(0.003)
Age	0.012	-0.007***	0.012	-0.007***
	(0.015)	(0.003)	(0.015)	(0.002)
N of Programmers	0.011	-0.001	0.011	-0.001
	(0.008)	(0.001)	(0.008)	(0.001)
N of Patent attorneys by region	0.011***		0.011***	
	(0.004)		(0.004)	
Average cost of patent applications by region			-0.169	
			(0.109)	
Constant	0.067	0.013*	0.642*	0.014**
	(0.044)	(0.007)	(0.372)	(0.007)
F statistic		9.74***		5.922***
Hansen J statistic				3.582**
Observations		5769		5769

Estimation method is two stage least square
Robust Standard Errors are in parentheses.
* p<0.1, ** p<0.05, *** p<0.01