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MOTOHASHI Kazuyuki
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Kazuyuki Motohashi[1]

Abstract

In Japan, the software patent system has been reformed and now software has become a patentable subject matter. In this paper, this pro-patent shift on software is surveyed and its impact on software innovation is analyzed. Before the 1990's, inventions related to software could not be patented by themselves, but they could be applied when combined with hardware related inventions. Therefore, integrated electronics firms used to be the major software patent applicants. However, during the period from the late 1990's to the early 2000's, when software patent reforms were introduced, innovative activities (measuring patent applications) by independent software development firms began.

We used datasets linking the IIP (Institute of Intellectual Property) patent database (individual patent datasets by using JPO's publication data) and firm level data from the Survey on Selected Services (software part) (METI) and the Basic Survey of Business Activity and Structure (METI). Based on the panel datasets from approximately 550 firms from 2001 to 2005, we found that patent applications from software firms gradually increased from the 1990's, while we were unable to find a direct impact of software patent system reforms. In addition, it was also found that patent application is positively related to a software company's independent strategy of subcontracting out system headed by large system integrators.

Keywords: software patent, innovation strategy, Japan

[1] Professor, Department of Technology Management for Innovation (TMI), University of Tokyo, 7-3-1 Hongo Bunkyo-ku Tokyo 113-8656 Japan. E-mail address: motohashi@tmi.t.u-tokyo.ac.jp, tel: +81-3-5841-1828, fax: +81-3-5841-1829

1. Introduction

The Japanese government published the Strategic Framework for Intellectual Property Policy in June 2003. The purpose of this policy is to enhance Japan's industrial competitiveness by promoting the creation, strengthening the protection, and promoting the utilization of intellectual property (IP). In addition, the Basic Law on Intellectual Property was established in November 2003, and led to action plans to promote the creation, dissemination, and effective exploitation of IP to contribute to the development of new industries. Implementation of this action plan involves various related ministries, and is coordinated by the Intellectual Property Policy Headquarters, headed by the Prime Minister.

Since the beginning of the 1990s, Japan's economy has been mired in long period of stagnation. Stimulation of business innovation is vital to breaking out of this confining situation. The Strategic Framework for Intellectual Property aims to encourage innovation through proactive actions plans for stimulating, effective use of intellectual property. Key elements of the Strategic Framework include so-called pro-patent policies, which involve speeding up patent examination procedures, revising the tort system, and protecting IP in new fields such as biotechnology and information technology (IT).

Against this background, one frequently encounters the argument that the pro-patent policies adopted by the U.S., which had been mired in decreasing competitiveness in the 1980s, provided the driving force behind today's rebirth of American competitiveness. Representative examples of pro-patent policies advanced in the U.S. in the 1980s include the establishment of the Court of Appeals for the Federal Circuit (CAFC) to specialize in appeals concerning patent infringement, and the extension of patent protections in the biotechnology and software fields. Such extension and strengthening of patent rights is argued to have stimulated business innovation, leading to the enhancement of US competitiveness. In addition, in the U.S., the amount of damage compensation in connection with patent disputes has recently soared. This increase may contribute to the trend towards the strengthening of patent rights as well.

However, even in the U.S., opinions are divided as to whether pro-patent policies to expand and strengthen patent protections have had any visible effects on business innovation. A wide range of factors influence the incentives for research and development (R&D) investment and new product development by businesses. These factors include the economic condition of the businesses, as well as expanding technological opportunities, and policy factors not related to the IP system (i.e. pharmaceutical safety regulations). Results of most analyses, primarily of U.S. cases, indicate that pro-patent policies have only marginal effects on business innovation (Kortum and Lerner (1999), Hall and Ziedonis (2001), and Lerner (2002)). In addition, one criticism of pro-patent policies lies in the "anti-commons" problem. Taking the pharmaceuticals field as an example, the anti-commons argument states that successive applications of patent protections to genetic innovations results in decreased R&D efficiency, by increasing the number of patent licenses required in order to conduct such R&D (Eisenberg and Heller (1998). Another vital issue concerns the goal of IP rights policies to promote the circulation of technology by providing incentives for business innovation and clarifying rights to established technologies. Granting excessive exclusive rights to specific technologies may impede the circulation of such technology.

This paper empirically investigates the role of software patents in innovations by software companies. Originally, software related invention could be protected by copyright. However, since copyright law ultimately protects expression, not ideas, protection of software under patent law also came under consideration. In the consideration of patent protection for software, issues arose concerning whether software qualifies under the patent law requirement that an invention include technological ideas along the line of natural science theory. Through the early 1990s, software itself, which consisted simply of calculation methods, was not considered to be subject to patent protection. However, software enabling the functioning of hardware, such as the Japanese language input system used in word processors, was allowed patent protection together with such hardware. In line with the increase in packaged software not embedded in hardware, in 1997 patent protection was allowed for software recorded on media such as floppy disks. In 2000, software was made eligible for patent protection as software itself, and in 2002 this protection was extended to software that circulates on computer networks.

In order to investigate the impact of software patent reforms, we have constructed the database of Japanese software firms by linking the IIP patent database and firm level data from the Survey on Selected Services (software part) (METI) and Basic Survey of Business Activity and Structure (METI). These datasets have been used for empirical analysis of innovation activities of software firms since the middle 1990's. The next section of this paper surveys a discussion on software patents as well as existing studies in this topic. Section 3 describes the dataset and the trend of patenting activities by software companies. Then, a section for econometrics analysis on software patent and innovation follows. Finally this paper concludes with a summary of findings and policy implications.

2. Survey of software the patent system and its economic impact

Granting patent rights for software began in the United States. In 1981, the Supreme Court stated that a mathematical formula, computer program, or digital computer" and a claim is patentable if it is embedded with equipment (Diamond v. Diehr). In 1994, the Court of Appeals for the Federal Circuit (CAFC) ruled in the In Re Alappat case that computer software is patentable per se by using the same non-obviousness and inventive step requirement. As a consequence of this court decision, the United States Patent and Trademark Office (USPTO) issued a comprehensive revision to examine guidelines for computer related inventions, explicitly indicating software as a patentable subject matter. In addition, the CAFC supported the patentability of business method (re State Street Bank) in 1998, which was followed by an explosion of business method patent applications.

In Japan, software became patentable in a similar way. First, the Japan Patent Office (JPO) issued examination guidelines in 1993, stating only computer software coupled with hardware inventions could be patented. In 1997, the JPO decided that storage media containing software could also be regarded as a patentable subject matter. This guideline was amended again in 2000 and software itself (including software provided online (without storage media)) has been patentable since then. Furthermore, in 2002, patent law was finally amended to designate explicitly “software” as a patentable subject. In terms of business method patents, such patent applications increased sharply in Japan as well after the State Street Bank case, but it was a temporary explosion since the agreement of examination guidelines by the European Patent Office (EPO), JPO and USPTO was only achieved in 2000.

In contrast to such movements, there are some arguments against software patents. It may be difficult to evaluate novelty and inventive steps in software invention. As a result, increasing low quality patents lead to higher probability in patent infringement. There is also a view that increasing the number of software related patents creates a dense patent thicket and does harm to innovation in the IT industry. It was found that a substantial share of patent applications is not for protecting the patent's invention, but for ensuring the flexibility of R&D in some technology fields (Graham and Mowery, 2003). This kind of motivation for patenting further pushes up the number of patent applications and blurs the boundaries between patent claims (as a result of the intangible nature of software), which may lead to increases in potential patent infringement cases and transaction costs in the technology market.

On the other hand, there are also views in favor of software patents. There some studies indicating that software patents are relatively higher in their economic value. Hall and McGarbie (2006) showed that marginal contribution to the Tobin's Q of a firm is higher for software patents than for other types. In addition, it was found that there is a positive relationship between the survival rate of internet startup companies since the IT bubble burst and the number of software patents (Cockburn and Wagner, 2007).

Software related inventions could be patented with hardware, even before system reforms were introduced. Therefore, recent reforms may not have a substantial impact on large electronics firms, who invent software as well as hardware. On the other hand, an impact can be found in purely software companies. Therefore, we focus on innovation activities in software companies since the middle 1990's in this study.

3. Data description and patenting activities of software companies

In this paper, we have constructed the datasets by linking the following three types of databases.

- IIP Patent Database: Individual patent database constructed from the JPO's patent publication information (Goto and Motohashi, 2007).
- Basic Survey on Business Structure and Activity (BSBSA): METI's survey data at firm level, annually conducted for all manufacturing, retail, wholesale and some service (including software) firms with 50 or more employees and capital of 30 million yen or more.
- Survey of Selected Service Industry: METI's survey data at establishment level, annually conducted for all establishments in some service area (including software).

Individual patent data by the IIP patent database is aggregated at the firm level by using applicant name and establishment level data from the Survey of Selected Service Industry, which is also aggregated at the firm level by using firm identifier information from each establishment. These two datasets are linked with firm level data by the BSBSA. We have selected software firms by picking up the firms with an 80% or more software output share by using line of business output information from the BSBSA. Finally, we have got about 550 samples for every year between 2001 and 2005, as well as only patent application information before 2001.

In this section, a trend of patent application of these software companies is surveyed. First, we have analyzed technology classifications of patents applied by software companies. A patent count by International Patent Classification (IPC) sub group is shown in Table 1.

(Table 1)

The following technology groups can be found frequently.

- Data processing system for the purpose of management, commerce and financial transactions (including e-commerce and business method): G06F17/60, G06F15/20,21 (version 4)
- Information systems and control inside computer: G06F12/, G06F13/
- Information retrieval and database structure: G06F17/30, G06F15/40 (version 4)
- Program control: G06F9/
- Digital computer in general: G06F15/
- Error detection: G06F11/

In Figure 4, a time trend of these patent applications is displayed. The patent count peaked in 1991 and decreased thereafter, but increased again in 2006. However, it should be noted that the multiple claim system was introduced in 1989 in Japan, and the number of claims per patent is still increasing. In this sense, it may be appropriate to look at the trend by the total number of claims. In term of this figure, a steady increase can be found until 2001, but it dropped in 2004 then went up recently. As is shown in the previous section, major system changes on software patents can be seen in 1997, 2000 and 2002. The number of patent application increases in 1997 and 2000, but not in 2002. It is difficult to evaluate the impact of such system changes by looking at macro figures.

(Figure 1)

These kind of macro figures are driven by firms with a large number of patent applications. Therefore, we have evaluated the software patent system change by using a diffusion index (increase=1, no change=0, decrease=-1) for each year. The results are indicated in Figure 2. The diffusion index for the total number of claims is positive until 1997, suggesting the number of firms with increasing claims surpasses the number of decreasing firms. This index becomes negative in 1998, which may be the result of a temporal patent application increase in 1997 due to the software patent system change in that year. On the other hand, the diffusion index moves up and down sharply after 2000, and it is difficult to explain such movement by system change. A surge of patent application in 2000 and 2001 may be explained by other factors such as the IT bubble and business method patent boom.

(Figure 2)

Finally, we have looked at the year when software firms applied for patents for the first time. When pro-patent system change is introduced, it becomes easier for a software company to file a patent application. In this case, its incentive for R&D increases, which may result in a patent application increase. At the same time, there are some software companies, that had never previously patented, which started patenting their inventions. Therefore, we can expect larger numbers of firms to start patenting after the middle 1990's. Figure 3 shows the number of firms by its first year of patent application.

(Figure 3)

The number of firms increases smoothly until the middle 1990's. It is interesting to see that a substantial number of firms had already applied for patents before the middle 1990's. We could not find any jumps at the year of the patent system change. Here, it should be noted that there is a time lag between increases in innovation incentives and patent applications. In addition, a large number of firms started applying for patents in 2000 and 2001, which may be explained again by the IT bubble and the business method patent boom. It is difficult to disentangle system change effect from these other factors.

4. Econometric analysis of patent and software innovation

In this section, the relationship between patent and innovation for software firms is further investigated by econometric analysis. How shall we measure software innovation? The patent can be used as an innovation output measure in many cases, but we treat patents as an innovation input in this paper, because our focus is to evaluate the impact of software patent system reform. We have looked at the increasing trend of patent application at Japanese software firms in the previous section. The question is whether this trend leads to innovation output for these companies.

Innovation output can be measured by the market value (Hall and McGarbie, 2006) or total factor productivity of firms (Minetaki and Motohashi, 2008). These indicators capture firm performance at the very end, so that it may be difficult to interpret and understand the results. Therefore, we use two indicators reflecting some mechanism of the relationship between patent and firm performance variables. One is the share of software sales to non software companies. The Japanese software industry can be characterized as a "multi-layered subcontracting system" (Minetaki and Motohashi, 2008). A subcontracting structure is headed by a large system integrator and multiple subcontracting software companies support such a structure. In many cases, subcontracting firms are small and lack the technological capability of independent businesses. The share of software sales to non software companies reflects the degree of dependency of such a subcontracting structure.

Another innovation output indicator is the share of prepackaged software sales. The dominance of such a subcontracting structure is related to the fact that large software users in Japan prefer custom made software instead of the prepackaged type (Motohashi,2006; Tanaka,2003). A system integrator modifies a software system adjusted to the individual needs of its customer, even in an application area where prepackaged software is available. This kind of supplier user practice requires a large system integrator which can deal with a large custom made software project. A small software vender cannot receive such a large order by itself, and subsequently deals with the subcontractor of large companies. However, there is a sign of growing small companies pursuing independent strategies by focusing on prepackaged software development. Therefore, the share of prepackaged software can reflect innovative activities at Japanese software firms.

Table 4 shows these innovation indicators by first patent application year. It is difficult to read any pattern from this chart, but it seems that there is a negative relationship between prepackage share and first patent application year. There may be substantial time lag between patenting and innovation output (either for de-subcontract or for prepackage share), so that the negative correlation is conceivable in cross sectional look.

(Figure 4)

We have conduced regression analysis of these two innovation indicators as dependent variables with following explanatory variables.

- Log (Patent): Log of number of patents holding

- Log (Emp): Log of number of employees (firm size)
- RD_share: Share of R&D staff of total employees
- SE_share: Share of SE (system engineers) of total employees
- Programmer_share: Share of programmers of total employees
- Year dummies

The regression results are provided in Table 2 (de-subcontracting share as a dependent variable) and Table 3 (prepackaged software sales share as a dependent variable). Models (1)-(3) are estimated by using the fixed effect model for panel data from 2001 to 2005. Models (4)-(6) are based on the IV method by using logs of R&D expenditure as an instrument variable for logs of the number of patents. Models (2) and (5) are estimated by using samples of firms which applied for patents for the first time after 1996, and Model (3) and (6) are estimated by using samples from before 1995.

(Table 2) and (Table 3)

First, the positive relationship between patent and innovation for the de-subcontracting share is observed in the fixed effect model estimation results. This finding implies that a firm under the subcontracting structure can become independent by developing its own technology. It should be noted that a positive association is observed, particularly in samples after 1996. Therefore, it may be the case that pro-patent reform after the mid 1990's contributes to software firms' innovative activities. However, in the IV models, the coefficient to patent log samples after 1996 is positive, but not statistically significant. As for prepackage sale share, we could not find statistically significant coefficients to patent log counts. Instead, the firm size matters with this index.

5. Conclusion

In Japan, the software patent system has been reformed and software is now a patentable subject matter. In this paper, this pro-patent shift on software was surveyed and its impact on software innovation was analyzed. Before the 1990's, inventions related to software could not be patented by themselves, but they could be applied by being combined with hardware related inventions. Therefore, integrated electronics firms used to be major software patent applicants. However, during the period of the late 1990's and early 2000's, when software patent reforms were introduced, innovative activities (measuring patent applications) by independent software development firms began.

We use the datasets linking IIP patent database (individual patent datasets by using JPO's publication data) and firm level data from the Survey on Selected Services (software part) (METI) and Basic Survey of Business Activity and Structure (METI). Based on the panel datasets for roughly 550 firms from 2001 to 2005, we found that patent applications from software firms gradually increased from the 1990's, but we could not find a direct impact of the software patent system reforms. In addition, it was also found that patent application is positively related to a software company's independent strategy of the subcontracting system headed by large system integrators.

The competitive standing of the software industry in Japan is notably low in terms of trade statistics, and its productivity is considered low in comparison to that of Europe and the United States (Imai and Ishino, 1993). This may be explained by the fact that labor intensive custom made software plays a dominant role in the Japanese software industry. In addition, the multi layered subcontracting system makes the situation worse, in the sense that small-scale subcontracting software firms lower the aggregated productivity level of the software industry. In this sense, pro-patent reform on software invention may induce independent strategies by in-house technological capabilities, and have a positive impact on the productivity in the Japanese software industry.

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Table 1: Patent counts by IPC sub group

	Ver. 2	Ver. 3	Ver. 4	Ver. 5	Ver. 6	Ver. 7	total
G06F17/60	0	0	461	0	137	1517	2115
G06F12/00	0	0	89	556	275	303	1223
G06F13/00	0	0	122	300	236	454	1112
G06F9/06	0	0	210	351	200	37	798
G06F17/30	0	0	111	0	158	495	764
G06F15/00	0	0	132	204	86	174	596
G06F15/20	0	3	175	321	0	0	499
G06F9/46	0	0	57	177	109	64	407
H04B7/26	0	0	227	88	20	24	359
G06F15/21	0	1	174	172	0	0	347
G06F15/60	0	0	119	222	0	0	341
G06F9/44	0	2	123	58	30	100	313
G06F11/28	0	1	26	136	78	70	311
G06F15/40	0	0	83	208	0	0	291
G06F3/06	0	0	32	123	51	69	275
H04L12/56	0	0	41	31	23	179	274
G06F15/16	0	1	23	146	76	22	268
G06F17/21	0	0	79	0	34	147	260
G06F19/00	0	0	26	0	113	109	248
H01L21/82	0	0	151	45	19	23	238
H04M3/42	0	1	22	77	73	62	235
G11C11/34	0	0	232	0	0	0	232
G06F3/14	0	0	12	111	74	31	228
G06F17/50	0	0	19	0	76	126	221
G06F15/62	0	0	97	119	0	0	216
H01L27/04	0	0	59	122	19	13	213
G06F1/00	0	0	88	62	30	28	208
G06F12/14	0	0	82	34	25	60	201
G06F11/34	0	0	22	81	36	56	195
H04L11/20	0	0	190	0	0	0	190
G06F11/22	0	1	22	106	40	19	188
H04M11/00	1	1	22	61	35	66	186
G06F3/12	0	0	35	78	29	37	179
G06F3/00	0	1	0	24	52	102	179
H04L13/00	0	1	174	0	0	0	175
G01R31/28	0	1	96	45	20	12	174
H04L12/28	0	0	23	21	49	73	166
G06Q50/00	0	0	0	0	0	162	162
A63F9/22	0	0	10	9	140	0	159
A63F13/00	0	0	23	0	0	135	158
H04L11/00	0	0	157	0	0	0	157
G06K17/00	0	3	16	46	40	51	156
H03K19/00	0	1	118	11	2	4	136
G06F3/033	0	0	8	36	65	27	136
H04L9/00	0	0	126	7	1	0	134
G06F11/30	0	0	13	44	34	41	132
G06Q10/00	0	0	0	0	0	127	127
G06F9/45	0	0	0	66	35	24	125
G06F15/30	0	1	66	51	0	0	118

Figure 1: Patent and claim counts of software firms' applications

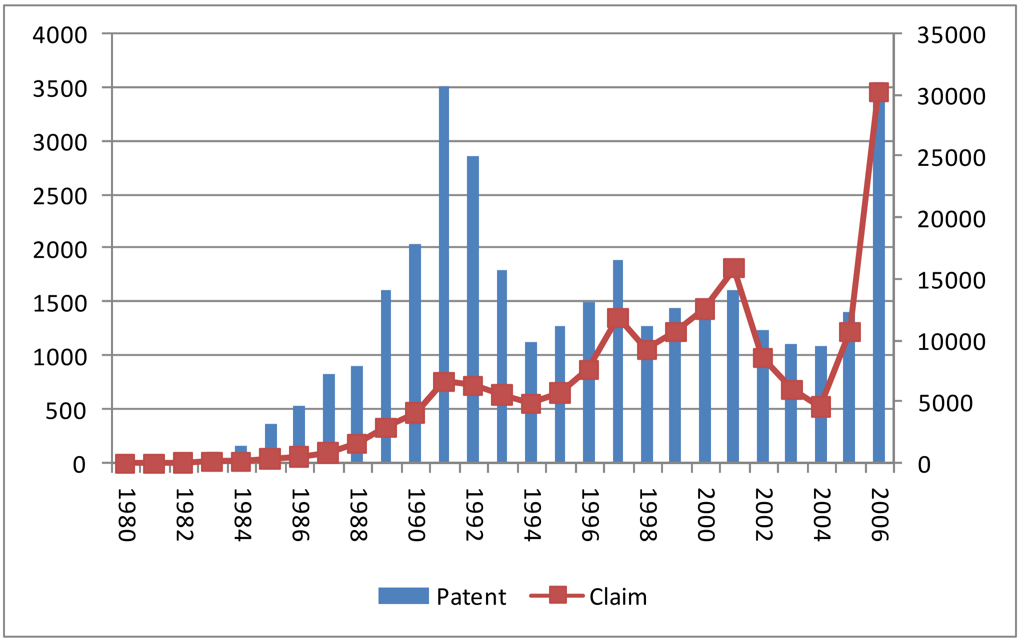

Figure 2: Diffusion indices of patent and claim counts

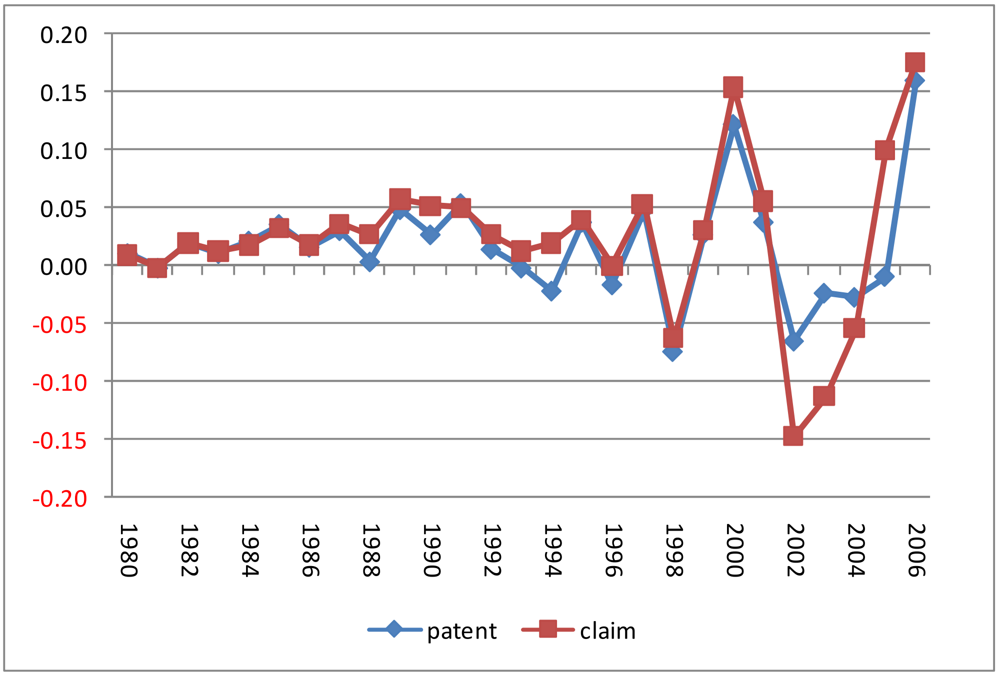

Figure 3: Number of firms by first patent application year

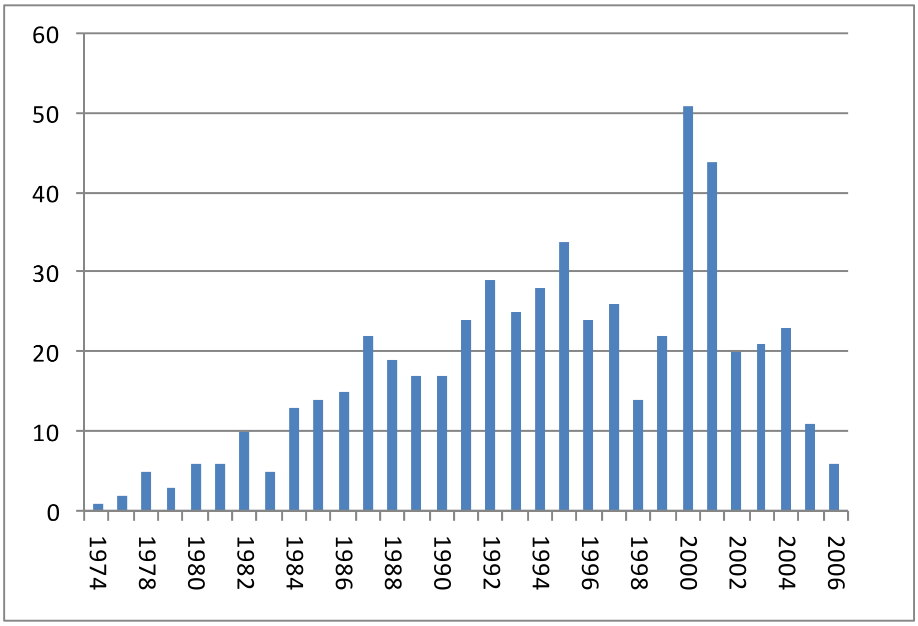

Figure 4: Innovation indicators by first patent application year

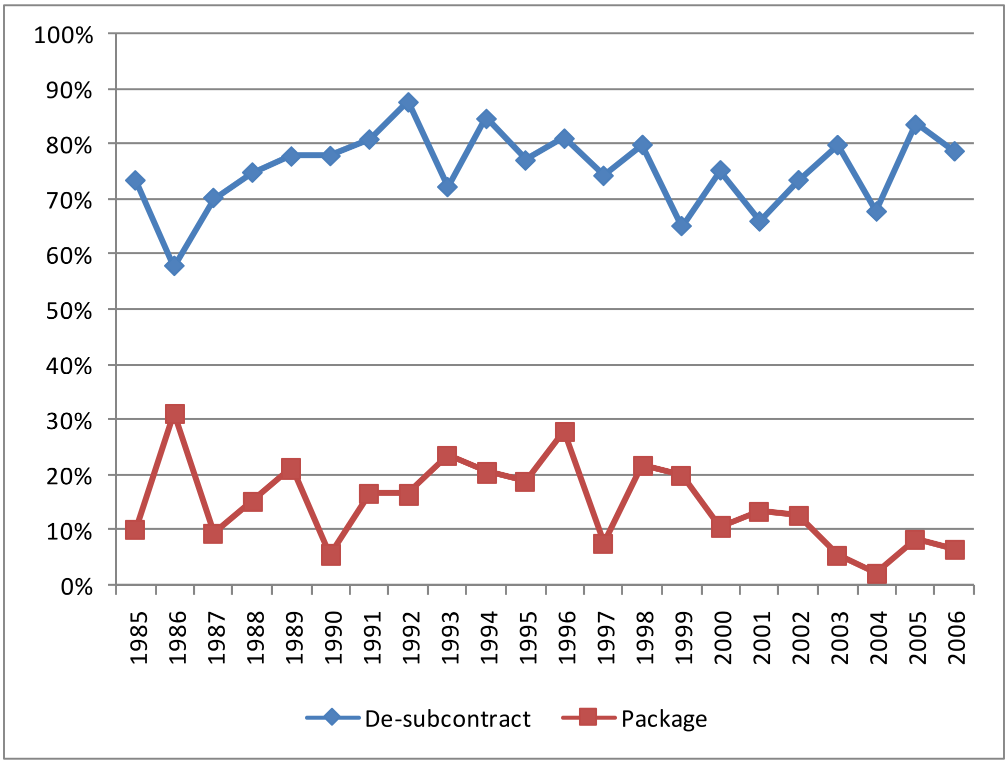

Table 2: Regression results (Dependent variable=De-subcontract share)

	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	IV	IV	IV
	all	1996-	-1995	all	1996-	-1995
Log(patent)	0.014	0.027	0.008	-5.244	1.020	-2.103
	(1.87)+	(1.93)+	(0.98)	(0.08)	(0.45)	(0.05)
Log(emp)	0.019	0.027	-0.005	1.010	0.060	1.401
	(0.72)	(0.85)	(0.12)	(0.08)	(0.38)	(0.05)
RD_share	0.496	0.543	0.351	6.144	1.082	3.781
	(3.83)**	(3.54)**	(1.36)	(0.08)	(0.46)	(0.06)
SE_share	0.022	0.008	0.037	0.055	-0.099	-0.199
	(0.65)	(0.18)	(0.71)	(0.05)	(0.28)	(0.03)
Programmer_share	0.014	0.085	-0.060	-0.262	-0.007	-0.391
	(0.34)	(1.52)	(1.09)	(0.10)	(0.03)	(0.07)
Constant	-0.366	-0.427	-0.217	-1.740	-0.881	-5.895
	(2.48)*	(2.37)*	(0.82)	(0.09)	(0.69)	(0.05)
Year Dummy	YES	YES	YES	YES	YES	YES
Observations	2586	1467	1119	1043	510	533
Number of kikatsu	691	396	295	351	185	166
R-squared	0.01	0.02	0.01			

Absolute value of t statistics in parentheses
+ significant at 10% ; * significant at 5%; ** significant at 1%

Table 3: Regression results (Dependent variable=Prepackage share)

	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE	IV	IV	IV
	all	1996-	-1995	all	1996-	-1995
Log(patent)	0.000	0.000	0.000	-0.217	0.648	0.242
	(0.02)	(0.02)	(0.02)	(0.22)	(0.44)	(0.30)
Log(emp)	0.120	0.120	0.120	0.080	0.008	-0.076
	(2.80)**	(2.80)**	(2.80)**	(0.34)	(0.06)	(0.11)
RD_share	0.201	0.201	0.201	0.805	1.460	0.002
	(0.81)	(0.81)	(0.81)	(0.78)	(0.91)	0.00
SE_share	0.004	0.004	0.004	0.015	0.009	0.013
	(0.08)	(0.08)	(0.08)	(0.16)	(0.04)	(0.05)
Programmer_share	0.111	0.111	0.111	-0.007	0.057	0.054
	(2.00)*	(2.00)*	(2.00)*	(0.06)	(0.28)	(0.19)
Constant	-0.568	-0.568	-0.568	-0.096	-0.125	0.365
	(2.26)*	(2.26)*	(2.26)*	(0.16)	(0.12)	(0.11)
Year Dummy	YES	YES	YES	YES	YES	YES
Observations	1047	1047	1047	998	489	509
Number of kikatsu	283	283	283	340	177	163
R-squared	0.02	0.02	0.02			

Absolute value of t statistics in parentheses
+ significant at 10% ; * significant at 5%; ** significant at 1%