RIETI Discussion Paper Series 17-E-098

To Support R&D or Linkages?
Seeking a better policy mix for SME support

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http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 17-E-098

July 2017

To Support R&D or Linkages? Seeking a better policy mix for SME support[1]

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Abstract

The innovation policy mix is reported to be increasingly targeted and demand side-oriented in recent years. In this context, an important question for policy makers, scholars, and analysts in Japan as well as in other nations is how to provide policy support to small- and medium-sized enterprises (SMEs). In this study, the effects of the new generation of policy mix supporting SMEs by the Ministry of Economy, Trade and Industry (METI) in Japan, the *Sapo-In* program, has been analyzed using patent data from the viewpoint of the effectiveness of financial support to firms (research and development (R&D) subsidy) and the support to build linkages (soft support) on both the supply- and demand-side (matching, brokering, and consulting). The results suggest that soft support has wider impacts in terms of patenting and internal and external network formation while financial support has very limited effects. Based on these results combined with information from the report on the follow-up monitoring survey of Sapo-In projects conducted by METI, the possibility of a better policy mix is discussed.

Keywords: Small- and medium-sized enterprise, Policy mix, Subsidy, Linkage, Patent data

JEL classification: D22, L14, L25, L52, O25, O34

[1]This study is conducted as a part of the project "Study on Industrial Innovation Capability and Innovation Infrastructure" undertaken at the Research Institute of Economy, Trade and Industry (RIETI). A part of this study has been conducted with the support of the Fondation France-Japon de l'EHESS (France). The author is grateful for the helpful comments and suggestions of Sadao Nagaoka (Tokyo Keizai Univ.), and Discussion Paper seminar participants at RIETI.

1. Introduction

Background

The existing literature shows that the role of government in encouraging innovation is becoming more important these days. For example, Block and Keller (2009) reported based on a unique data set of prize-winning innovations between 1971 and 2006 that the role of public institutions and public funding in the innovation process is expanding. They also pointed out that the role of inter-organizational collaboration in innovation is expanding and that the role of small- and medium-sized enterprises (SMEs) is increasing. Although their data set is highly weighted towards cases in the USA, we can find similar trends almost all over the world (O'Sullivan et. al, 2013; Warwick and Nolan, 2014; Dheret et al., 2014). Most countries have a variety of policies to address or overcome specific weakness in their innovation systems.

There have been longstanding arguments between supply-side and demand-side policies in economic literatures as well as in the field of innovation policy (Guerzoni and Raiteri, 2015). In addition, even among supply-side policies such as R&D subsidies and tax credits, pros and cons have been extensively discussed in terms of effectiveness and efficiency (OECD, 2015). In terms of the innovation policy mix, Mohnen and Roller (2005) found that evidence regarding the existence of complementarity in policies depends on the phase of innovation (propensity or intensity) as well as the particular pair of economic policies. They also found that evidence regarding the propensity to innovate suggests a number of complementary relationships in innovation policy. On the other hand, substitutability among policies seems more often the norm as far as the intensity of innovation is concerned. According to the OECD (2016), the balance in the innovation policy mix as a whole is changing from the combination of generic instruments to population-targeted (for example, SMEs) instruments and sector- or technology-targeted instruments. The report also shows that the balance in policy instruments is changing from supply-side to demand-side, although the supply-side instruments remain dominant.

Japan is known to be one of the least entrepreneurial societies (GEM 2014 Global Report) and there is a great productivity gap between large firms and SMEs. However, in the meantime, SMEs are the foundation of Japan's labor market and essential for Japan's economic growth. Under such circumstances, there should be no doubt that government support to SMEs is one of the most important targets for innovation policy in Japan.

In this study, I shed light on the new generation of SME-supporting policy mix, the Sapo-In program, by the Ministry of Economy, Trade and Industry (METI) in Japan. The effectiveness of the policy mix from the viewpoint of the financial support to firms (R&D subsidies) and the support to build linkages on both the supply- and demand-side (matching, brokering, and consulting) will be analyzed using patent data.

SME and SME support policy in Japan

Based on the 2014 Economic Census in Japan, SMEs[2] account for 99.7% and 70.1% of

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[2] In Japan, the official definition of SME is as follows:
In the manufacturing, construction and transport sector: firms with no more than ¥300 million in capital or

the number of firms and employees, respectively (Small and Medium Enterprise Agency, 2016). However, they account only for 50.6% of the amount of value added for the manufacturing industry and 6.5% of exports. For example, in the manufacturing sector, the productivity gap between large firms and SMEs is 2.4-fold in Japan, whereas it is 1.8-fold in Germany, 1.7-fold in UK and 1.5-fold in France (Table 1). As such, the position and the productivity level of SMEs in Japan are much lower than in other countries and pose a serious issue for the whole economy.

<Table 1 here>

Support for the R&D activity of SMEs has long been one of the major targets in the policy agenda of many countries. For example, supporting SMEs in their development, especially in relation to their innovation performance, is considered to be instrumental in increasing regional competitiveness and employment (European Commission, 2014). "Enhancing the competitiveness of SMEs" is one of the 11 thematic objectives for Cohesion Policy in 2014-2020 (See Regulation (EU) No 1303/2013). Today, the "SME Instrument" is the renovated funding program package under Horizon 2020 and is dedicated to the development of innovative SMEs across Europe.

SME support policy in Japan also has a long history. In 1963, the original Small and Medium Enterprises Basic Act had been enacted, which recognized SMEs as socially vulnerable. The basic principle at that time was to rectify disparities between firms in terms of productivity and capacity. Therefore, policy instruments that were introduced gave financial support for modernization of SMEs' facilities and prevented delays in payment of subcontract proceeds, etc., to ensure that transactions between main subcontracting entrepreneurs and subcontractors were fair, and so on (Matsushima, 2014). The targets of those instruments were not set to an individual firm but to a specific industry. The government was reluctant to support a specific firm as it was designed to be a kind of social policy rather than an innovation policy.

The basic principle of SME support policy in Japan has changed drastically since 1999. The revised version of the SME Basic Act declared that SMEs are the basis of the Japanese economy and one of the sources of innovation by recognizing their diversity and dynamism in growth and development. Thereafter, the policy targets of SME support have been set to an individually motivated firm that helps itself. A series of new generation policy mixes have been implemented to support creation of new technologies, products, businesses, and relations by SMEs. METI's Sapo-In program, targeting highly motivated firms in specific industries, can be regarded as a new generation policy mix and implemented as a major instrument for supporting SMEs in the manufacturing industry.

2. METI's Sapo-In program

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firms with no more than 300 regular employees.
In the wholesale sector: firms with no more than ¥100 million in capital or firms with no more than 100 regular employees.
In the service sector: firms with no more than ¥50 million yen in capital or firms with no more than 100 regular employees.

The Sapo-In program, whose name is derived from "supporting industry," was launched in 2006 based on the Act on Enhancement of Small- and Medium-Sized Enterprises' Core Manufacturing Technology and Strategic Core Technology Advancement. A supporting industry also known as one of the essential elements of Michael Porter's "Five Forces Model," typically provides raw materials, parts, or devices for downstream assembly industries such as automotive, electronics, and machinery. The core twenty manufacturing technologies to be developed are specified by METI as casting, molding, cutting, metal stamping, plastic molding, embedded software, electronic devices, powder metallurgy, plating, fermentation, forging, fiber processing, heat treatment, welding, positioning, power transmission, binding, chemical synthesis, thermal spraying, and vacuum creation. METI invites R&D project proposals from SMEs that are targeted to develop any kinds of those technologies. A proposal needs to have a defined schedule towards market launch and the sales prediction. Special emphasis has been set on the support to consortium which consists of multiple SMEs and/or SMEs' customer firms (in some cases, a large firm). The involvement of universities and/or public research institutes (national and regional) as consortia members or advisors is strongly encouraged.

The Sapo-In program is distinguished by its two-step selection process. In the first step, project proposals are screened to be certified as an appropriate plan at METI's local bureau. The Organization for Small & Medium Enterprises and Regional Innovation—one of the Independent Administrative Institutes attached to METI—may give support to SMEs throughout the process, from the preparation phase to the market launch. In addition, in many cases, local non-profit organizations such as industrial promotion centers, technology transfer offices, or for-profit consultation firms are involved to give supports (soft supports) from the very early phases. They contribute in terms of networking, documentation, progress monitoring, and, sometimes, project management. The SMEs and projects that have been certified will be published by METI. SMEs with certified Sapo-In projects gain the following benefits:

– The right to apply for a "Sapo-In" subsidy
– Patent cost abatement (fees for the exam request and registration will be halved)
– Low-interest loans by the government-affiliated financial institutions (maximum amount of ¥270m and maximum tenure of 20 years)
– Extended credit guarantee for SMEs (basic credit guarantee to be doubled in addition to unsecured credit guarantee, new business credit guarantee, etc.)
– Extended stock underwriting (the government-affiliated financial institution can underwrite for stock increase in the case of capital over ¥300m)

Next, SMEs can apply their project proposals to request a R&D subsidy. The second step will be conducted by the expert review committee at the Small and Medium Enterprise Agency (SMEA) and the name of beneficiaries will be published. Selected projects gain a two- or three-year subsidy (with maximum amounts of ¥45m, ¥30m, and ¥22.5m for the first, second, and third year, respectively). The outcomes of the projects, that is., established technologies and products, will be published and those SMEs will be subjected to the follow-up monitoring after the completion of the project.

The Sapo-In program started in 2006, and 399 projects were certified in the first year, of which 158 (40%) were collaborative (multi-SMEs) projects (Table 2). The number of certified projects per year decreased in the second and third years, then increased to reach 1,050 in the year 2010, although the proportion of collaborative projects decreased steadily to 19%. As the number of projects that were granted two-year subsidies are relatively small and fluctuate year to year, I have limited the subject of this study to projects that were granted three-year subsidies. As shown in Table 2, the total number of three-year subsidy projects is 390, which accounts for 16% of the certified projects.

<Table 2 here>

Table 3 shows the breakdown of the projects' technology fields. Among certified projects, the "embedded software" field has the largest number, while among subsidized projects, "molding" and "casting" are placed equally at the top. Table 4 shows the breakdown of geographical location of the projects. Tokyo, Osaka, and Kanagawa, the three highest populated cities in Japan, have predictably the largest numbers of certified projects. However, the rate of receiving subsidies was unexpectedly low in the Kanto area, including Tokyo and Kanagawa.

<Table 3 here>

<Table 4 here>

Table 5 shows the involvement of advisors and external project managers in subsidized projects.[3] The frequent involvement of downstream customers may well be understood as the customers' needs are crucial for the supporting industry and they sometimes inspire SMEs' R&D activities. On the other hand, the involvement rate of universities looks surprisingly high. Many projects even invite multiple advisors from universities (data not shown). In addition, regional technology centers, that is, *kosetsushi*, local government-founded and operated R&D centers, contribute to almost half of the subsidized projects. Combining this data with the high involvement rate of non-profit organizations as project managers suggests that the local government and society play an important role in supporting SMEs.

<Table 5 here>

As mentioned above, the total number of Sapo-In certified projects started during 2006 and 2010 was 2,429. Some projects have involved multiple SMEs and some SMEs have been involved in multiple projects. Therefore, in terms of the number of SMEs, a total of 2,628 firms

[3] Unfortunately, this information is only available for subsidized projects.

have contributed to more than one project of which 1,994 were principal applicants of the projects (Figure 1). The remaining 634 firms have contributed only as non-principal applicants (collaborators). As for the subsidized projects, a total of 540 firms have contributed, out of which 368 did so as principal beneficiaries and the remaining 172 did so only as non-principal beneficiaries. About 90% of subsidized projects received the first year subsidy in the same year of certification or in the next year.

<Figure 1 here>

3. Analytical framework and results

Research question and research design

Nishimura and Okamuro (2011) addressed the research question on the support programs of the cluster policies, that is, which kind of support, direct R&D subsidies or indirect networking/coordination support, contributes more to firm performance. This study sheds light on essentially the same topic but from a broader viewpoint. The Sapo-In program is a combination of multiple policy instruments with their specific targets. The subsidy which is only available after the highly competitive second selection step is to support R&D project implementation and is expected to contribute to building the SME's new core competence. Indirect financial supports, including low-interest loans, credit guarantees, and/or stock underwriting, are available after the first step certification. The target for those aids is to overcome financial limitation and to encourage SMEs' investment in new business-related activities that is, patenting, marketing, and/or facility investment. Networking support for building linkages is available even before the application for certification. In fact, we may suppose that an action of application for certification itself is the sign of contribution by networking intermediary organizations, as we can see that the majority of subsidized projects, 321 out of 390, had reported some kind of external organization as a project coordinator/manager from the time of formation of the research consortia (unfortunately, the data is not available for all certified projects). On the supply-side, networking with universities and/or public research institutes is expected to enhance SMEs' technological capability and opportunity while linkages on the demand-side with customers is expected to contribute to widening and upgrading SMEs' supply-chain (sometimes referred to as "*keiretsu* break").

How can we know the effectiveness of these policy instruments? In this study, I employ a kind of patent indicator as the output measure for firm performance. The number of patent applications may be the simplest output measure for a firm's R&D activity. Generally, the number of patent applications is a noisy output measure (Griliches, 1990) because the value of patent varies a lot (Suzuki, 2011) and many firms, mostly big ones, may make patent applications due to strategic reasons, not necessarily to use that technology (Blind et al., 2009). Although SMEs are supposed to think more seriously about practical usage of the patent when they file it, it would be more appropriate to use value-weighted patent indices. The number of patents granted and

the patent family size are based only on those patents which are expected to be able to compensate the cost for patent registration/maintenance and the cost for international patent applications. The number of forward citations the patent receives is another well-known value-weighted patent measure. As for Japanese patent data, most citations come from patent examiners when they reject newly applied patents. So, the number of forward citations can be regarded as the measure for the practical exclusionary value of the patent (Suzuki et al., 2015).
The number of co-applicants can be used as a measure of supply-side external linkages. If this measure increases during or after the Sapo-In project, it may show the consequence of networking activity supported by the coordinator when preparing and/or implementing the project. Additionally, the number of co-inventors can be regarded as the measure for linkages among researchers which are not limited to internal but also external.

We need to be careful about the time lag when using these indices. Patent cost abatement for Sapo-In certified SMEs is only available for those patents applied to the Japan Patent Office during the project or within two years after the end of the project. Moreover, patent registration and citation need longer lags to be made after the application of the patent.

The data

Data on Sapo-In projects certification (results of the first selection step) was drawn from the published records of METI's regional bureaus. The results of the second selection step, subsidy beneficiaries, and the final reports of those projects were drawn from the published documents of the SMEA under METI. Patent data was drawn from the 2015 edition of the Institute of Intellectual Property Patent Database (IIP-PD) and the 2017 spring edition of the European Patent Office's Worldwide Patent Statistical Database (PATSTAT). Patent data covers the years 2001 to 2012. Figure 2 shows the trends in the number of patent applications to JPO by all applicants (blue bars: 1/100 scale) and Sapo-In certified firms (red bars). The number of patent applications to JPO exhibits a decreasing trend in the 2000s. The number of patent applications by Sapo-In certified SMEs roughly account for 0.7% of the total applications. Please note that the values in 2012 and later are considered to be affected by the data time lag.

<Figure 2 here>

The unit of analysis in this study is individual firm (i) – year (t). The data set forms a balanced panel. As mentioned before, sample firms consist of SMEs which have at least one certified Sapo-In project started between 2006 to 2010 (treatment group: 2,628 firms) and SMEs without a Sapo-In project during the same period (control group: 1,000 firms; see Figure 1). The names of potential control group SMEs were extracted by stratified sampling based on the distribution of the number of patent applications per year and the composition of the technology fields (IPC sections) of the treatment group from 2001 to 2005. Then, only those firms fitting the definition of SME were incorporated into the control group samples.

The model

I employ the standard panel negative binomial with fixed-effect model after Hausman et al. (1984) and Hall et al. (1986). The equation for the model becomes:

$$Y_{it} = \beta X'_{it} + \alpha_i + \delta_t + u_{it} \qquad \text{[EQ-1]}$$

Where

- Y_{it} is the dependent variable where i = firm and t = year.
- X'_{it} represents a vector of independent variables,
- β is the coefficient for a vector of independent variables,
- α_i (i=1 to 3625) is the intercept for each firm (firm-specific effect),
- δ_t (t=1 to 12) is the intercept for each year (year-specific effect),
- u_{it} is the error term.

Dependent variables:

$Numpat_{(it)}$: the total number of patent applications by the $firm_{(i)}$ in the $year_{(t)}$.

$Num\_patG_{(it)}$: the total number of granted patents applied by the $firm_{(i)}$ in the $year_{(t)}$.

$Fam\_size_{(it)}$: the total number of related patent documents including foreign patent offices for which the patents were applied (known as patent family size) by the $firm_{(i)}$ in the $year_{(t)}$ with priority application.

$Fwd\_cit_{(it)}$: the total number of forward citations that the patents applied by the $firm_{(i)}$ in the $year_{(t)}$ received.

$Coappl_{(it)}$: the total number of co-applicants of the patents (except for the $firm_{(i)}$ itself) of the $firm_{(i)}$ in the $year_{(t)}$.

$Coinv_{(it)}$: the total number of inventors of the patents which were applied by the $firm_{(i)}$ in the $year_{(t)}$.

Independent variables:

$Certify_{(it)}$: dummy variable indicating if the $firm_{(i)}$ in the $year_{(t)}$ has Sapo-In certified R&D project (= 1) or not (= 0). This variable stays 1 for 5 consecutive years after the certification of the project, taking time-lag into account.

$Principal_{(it)}$: dummy variable indicating if the $firm_{(i)}$ in the $year_{(t)}$ is granted a Sapo-In subsidy as a principal beneficiary (= 1) or not (= 0). This variable stays 1 for 5 consecutive years after the granting of the subsidy, taking time-lag into account.

$Non\_pr_{(it)}$: dummy variable indicating if the $firm_{(i)}$ in the $year_{(t)}$ is granted a Sapo-In subsidy only as a non-principal beneficiary (= 1) or not (= 0). This variable stays 1 for 5 consecutive years after the grant of the subsidy, taking time-lag into account.

Control variables:

IPC_A to $IPC\_H_{(it)}$: dummy variables indicating if the $firm_{(i)}$ in the $year_{(t)}$ applied patents with the primary IPC in the section A (to H) or not. This is to control different propensities to patent among technological fields.

$Year_{(t)}$: dummy variables for each year from 2001 to 2012. This is to control over all time trend in the number of patent applications. The standard year is set to 2001.

Appendix Table 1 shows the descriptive statistics for the variables.

Regression results

The statistical software Stata 12 was used to perform conditional fixed-effects negative binomial estimations. Some firms have been dropped from the panel data because of all zero outcomes (1,153 out of 3,625 firms for *numpat*, for example). Over-dispersions of dependent variables are confirmed, which suggests that the negative binomial model fits better than the Poisson model. In addition, the appropriateness of the fixed effects model was confirmed based on the results from the Hausman test. Table 6 shows the summary of the estimation results (see details in the Appendix Table 2).

The coefficients of *certify* show that it has highly significant positive effects on almost all patent indices. SMEs apply more patents after getting the Sapo-In certification, which implies the enhancement in their R&D activity. Moreover, SMEs' patents applied after the Sapo-In certification tend to have multiple applicants as well as a greater number of inventors which implies that the R&D collaboration network among external and/or internal researchers was enhanced. The coefficients of *principal* show that it has virtually no effect on any of the dependent variables. Receiving a subsidy seems to have a very limited effect on the beneficiary's R&D activity in terms of patent. The coefficients of *non_pr* show that it has highly significant negative effect on *fam_size*. SMEs which are involved in Sapo-In projects only as a collaborator tend to have domestic-only patent applications and might not find it necessary to get international patent rights.

<Table 6 here>

Figure 3 consistently shows the trends in the average percentage of patent applications before and after Sapo-In projects by Sapo-In certified and subsidized firms who have at least one patent from 2001 to 2012. Lag length for one-year which means the next year from receiving certification has the peak (in blue bars) in the average percentage of patent applications. Also, very similar results (in red bars) can be observed for the beneficiaries of the subsidy.

<Figure 3 here>

4. Discussions

Nishimura and Okamuro (2011) reported, based on the results from their original questionnaire survey, that firms who received support from the Industrial Cluster Program by METI have expanded the industry–university–government network. They also reported that indirect support, for example, networking with related organizations, dispatch of coordinators, and information transmission, has an extensive and strong impact on beneficiaries' performance whereas direct R&D support by subsidy has only a weak effect. My results seem to be consistent with their findings as well as more recent studies (e.g., Martin et al., 2011; Okubo and Tomiura, 2012; Okubo and Okazaki, 2015) but can contribute to broadening the scope beyond the cluster policy.

In 2013, the SMEA published a report on the economic ripple effect of the Sapo-In program. In that report, direct and indirect effects of Sapo-In on SMEs in terms of increase in value added as well as the industry-wide production-inducing and job creation effect had been estimated based on the data from follow-up monitoring surveys and interviews utilizing the BETA-method (Bach et al., 2005). According to the report, the total amount of SME-created value add was 1.8 times the amount of subsidies, the production of about ¥58 billion was induced, and 3,080 jobs were created. Although the report concludes that the Sapo-In program may have a satisfactory cost/benefit ratio and multiplier effect, the analysis was based only on the cases from extremely successful subsidized SMEs. The vast majority of the subsidized firms had not reported any amount of sales at that time and the cases on the firms who had certified R&D projects but were not subsidized have not been analyzed at all. It might be difficult to justify the amount of subsidies spent by the results reported in the SMEA's report as it is possible that those successful firms could have reached the market even without the subsidy. We can understand the true direct effects of subsidies only by comparing the performances of firms between the treatment and control groups (and pre- and post-grant). The results from this study as well as previous studies, suggest that if a SME participates in a contest, that motivated firm has a good chance to succeed even without an award. However, we need to know better about the economic performance of those subsidized firms as well as the firms who had certified R&D projects but were not subsidized in the longer-term. That is an agenda for the future.

The Sapo-In program can be regarded as a kind of contest with an award-winning (subsidy) rate of 16% (see Table 1). Many existing studies on incentives for innovation suggest that prize awards can be a good mechanism for accelerating technological development (e.g., Scotchmer, 2004; Kremer and Williams, 2009; Brunt et al., 2012). Then the tradeoff may exist between number and size of awards. In general, fewer awards of the same amount will reduce the number of applications while fewer awards with increased value can sometimes encourage applicants to participate in the contest. According to Clancy and Moschini (2013), grant-making agencies in the United States experienced this phenomenon in the early 2000s: when the National Institutes of Health reduced the number of awards offered after 2002 due to a tightening budget, the number of applications fell. Conversely, when the National Science Foundation reduced the number of awards offered between 2000 and 2005, but increased the value of each award, the number of applications per researcher actually increased. If the primary target of Sapo-In is set to encouraging SMEs to participate in innovative activity, the optimal balance between number and size of awards should be explored. We also need to remember the risk that a system of government prizes may bring micromanagement to innovation. The government would determine the "shadow prices" of inventions, pick up the winners, and pay rewards to them. In this setting, if only the government could find the right technology and prices, it could replace market mechanisms with government prizes. However, the premise is inconsistent with experience in centrally planned economies (Spulber, 2014). Too strong of an intervention may distort the market for technology. Blunt et al. (2011) pointed out the usefulness of a prize categories rotation scheme. It may mitigate the risk of "Galapagos Syndrome" that they foster only domestically "hot" technology sectors.

The last point I would like to mention is the classic agency problem (Akerlof, 1970). How can government avoid giving certifications or subsidies to lemons (bad projects)? One important mechanism to address this problem is having a close relationship with SMEs (Lerner, 2002) to conduct intensive monitoring. As shown in Table 5, the large majority of Sapo-In subsidized projects already involve external project managers who, in many cases, provide coordinating support at the beginning phase as well as project progress management. They are supposed to be specialists in the technology fields and should know the project very well. METI (or SMEA) may give more support to those coordinators/monitors as intermediaries' function is critical to fill the information gap. It may also encourage the networking activity which leads to enhancement in "linkages."

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Tables and Figures

Table 1: Comparison of labor productivity per working hour in four selected countries in 2013

	SMEs in manufacturing	Large firms in manufacturing
Japan	24.6	60.0
Germany	31.3	54.3
France	29.7	46.1
UK	31.5	55.3
in PPP converted $US/man-hour		

Based on the Fig. Column 1-3-2 (2) in "The 2016 White Paper on Small and Medium Enterprises in Japan"

Table 2: The number of certified and three-year subsidy-granted projects of Sapo-In from 2006 to 2010

Year	Certified projects			Subsidized projects	
		Collaborative			
2006	399	158	(40%)	50	(13%)
2007	218	61	(28%)	72	(33%)
2008	184	47	(26%)	40	(22%)
2009	643	147	(23%)	39	(6%)
2010	1050	200	(19%)	189	(18%)
	2494	613	(25%)	390	(16%)

Table 3: Breakdown of technology fields of Sapo-In projects

Technology field	Certified projects	Subsidized projects
Embedded Software	366	23
Cutting	289	39
Electronic Devices	219	23
Molding	210	43
Plastic Molding	187	27
Casting	160	43
Metal Stamping	158	33
Fermentation	115	18
Plating	112	19
Positioning	107	13
Chemical Synthesis	95	9
Welding	75	14
Heat Treatment	70	15
Fiber Processing	67	16
Forging	60	16
Vacuum	51	5
Power Transmission	48	11
Powder Metallurgy	45	9
Binding	33	9
Thermal Spraying	27	5
	2494	390

Table 4: Breakdown of geographical location of Sapo-In projects.

Prefecture	Num. certified projects	Certified projects region total	Num. subsidized projects	Subsidized projects region total		Prefecture	Num. certified projects	Certified projects region total	Num. subsidized projects	Subsidized projects region total
Hokkaido	76	(Hokkaido-	13			Shiga	49	(Kinki)	5	
Aomori	6	Tohoku)	1			Kyoto	78		9	
Iwate	35		6			Osaka	236		49	
Akita	28		6			Hyogo	85		17	
Miyagi	52		10			Nara	19		5	
Yamagata	15		3			Wakayama	14		4	
Fukushima	19	231	0	39 (17%)		Fukui	29	510	7	96 (19%)
Ibaragi	76	(Kanto)	7			Okayama	40	(Chugoku-	9	
Gunma	55		5			Hiroshima	41	Shikoku)	10	
Saitama	122		13			Tottori	16		5	
Tochigi	30		4			Shimane	6		1	
Chiba	49		6			Yamaguchi	11		2	
Tokyo	326		31			Tokushima	19		1	
Kanagawa	186	844	21	87 (10%)		Kagawa	18		2	
Yamanashi	32	(Chubu)	7			Kochi	9		2	
Niigata	59		9			Ehime	19	179	3	35 (20%)
Shizuoka	105		17			Fukuoka	55	(Kyusyu)	13	
Nagano	47		6			Oita	3			
Aichi	199		33			Saga	9		2	
Mie	46		6			Nagasaki	4			
Gifu	68		17			Kumamoto	19		3	
Ishikawa	31		10			Miyazaki	5			
Toyama	36	623	7	112 (18%)		Kagoshima	3			
						Okinawa	9	107	3	21 (20%)
							2494		390	

Table 5: Involvement of advisors and external project managers in subsidized Sapo-In projects

Invited advisors	projects
Downstream customer	220
University	309
National research institute	63
Regional technology center	186
External project manager	**projects**
Yes (non-profit organization etc.)	321
No (self managed)	69

Table 6: Summary of the estimation results

		Independent variables				
Dependent var	numpat	num_patG	fam_size	fwd_cit	coappl	coinv
certify	+++	+++	+++	++	+++	+++
principal						
non_pr			−−−			−

Figure 1: The total number of firms in Sapo-In projects and the make-up of samples

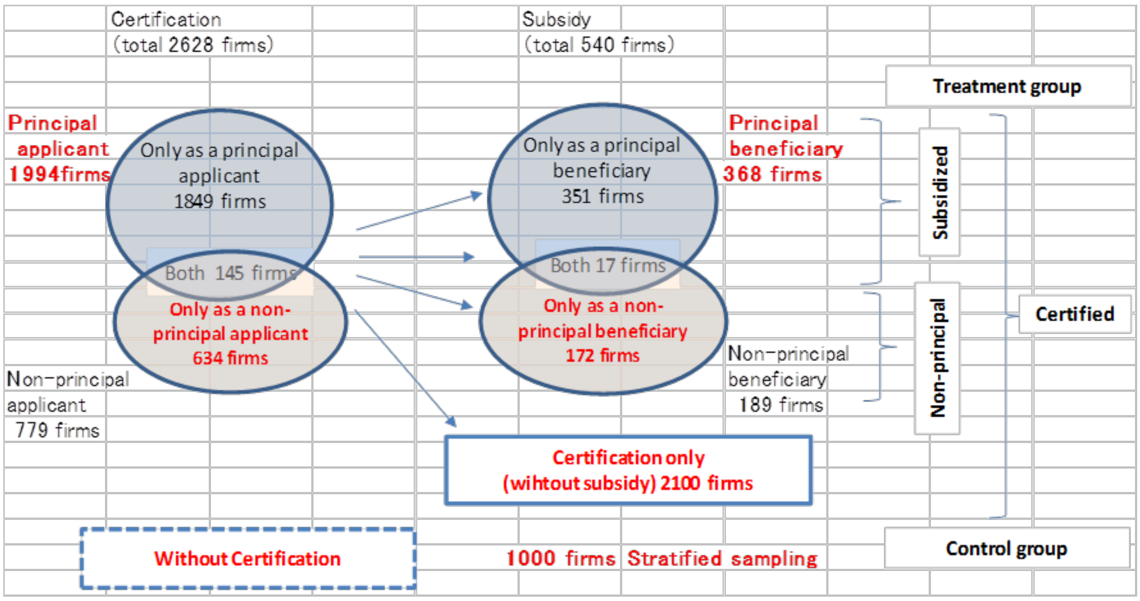


Figure 2: The number of patent applications to the Japan Patent Office

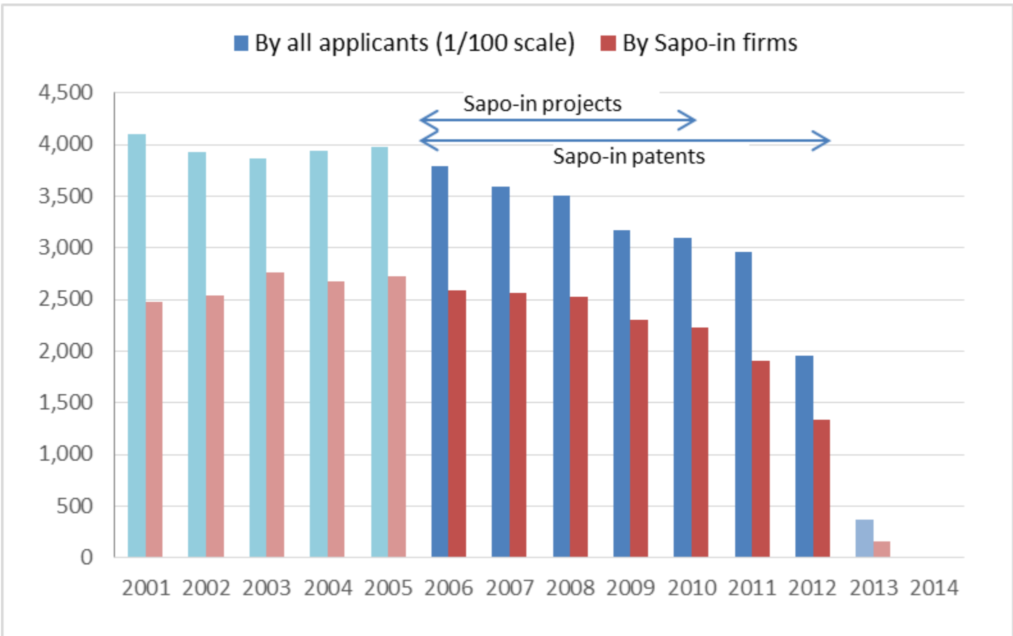
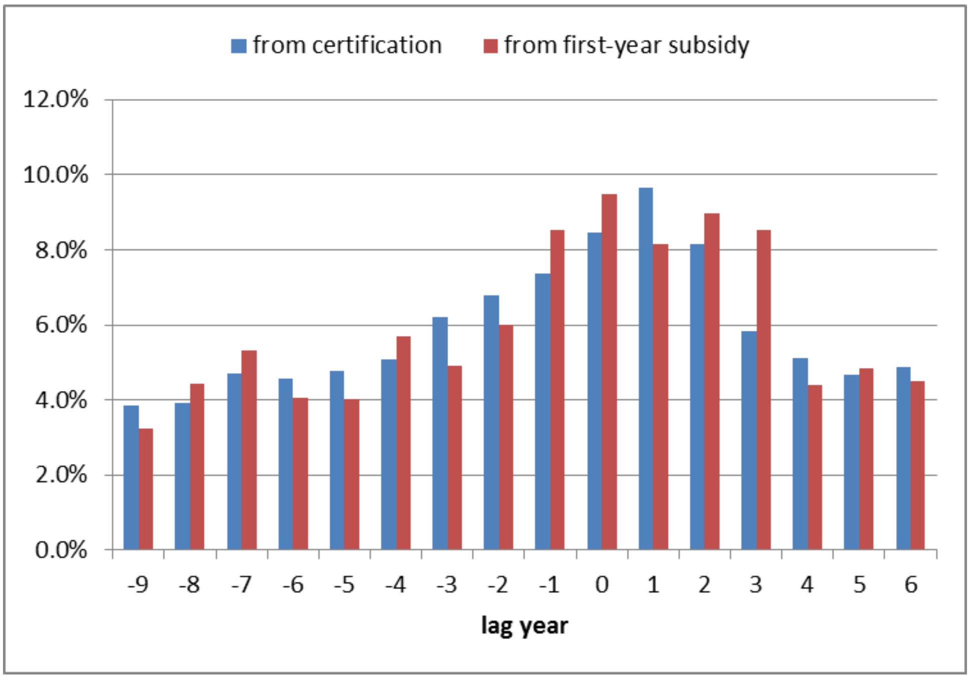


Figure 3: The distribution of the average percentage of patent applications before and after Sapo-In projects



Appendix Table 1: Descriptive statistics for variables

Variable	Mean	Std. Dev.	Min	Max
Dependent var				
numpat	0.87	3.53	0	161
num_patG	0.41	1.77	0	78
fam_size	1.27	5.62	0	198
fwd_cit	2.05	10.67	0	477
coappl	0.35	1.42	0	37
coinv	2.30	9.29	0	588
Independent var				
certify	0.26	0.44	0	1
principal	0.05	0.22	0	1
non_pr	0.02	0.14	0	1
IPCA	0.05	0.21	0	1
IPCB	0.09	0.29	0	1
IPCC	0.05	0.23	0	1
IPCD	0.01	0.09	0	1
IPCE	0.01	0.12	0	1
IPCF	0.04	0.18	0	1
IPCG	0.07	0.25	0	1
IPCH	0.05	0.22	0	1

Appendix Table 2: Regression results

Conditional FE negative binomial regression (xtnbreg)

	(1)			(2)			(3)		
Dependent var	numpat			num_patG			fam_size		
Num obs.	29,640			21,984			29,592		
Num firms	2,470			1,832			2,466		
Obs per firm	12			12			12		
Wald chi2(23)	13,212			5,093			15,589		
Log likelihood	−20,565			−13,181			−24,081		
certify	0.121	(0.025)	***	0.091	(0.034)	***	0.121	(0.027)	***
principal	0.009	(0.041)		0.064	(0.053)		0.066	(0.043)	
non_pr	−0.080	(0.071)		−0.049	(0.094)		−0.285	(0.076)	***
IPCA	0.634	(0.024)	***	0.560	(0.034)	***	0.684	(0.026)	***
IPCB	1.062	(0.020)	***	0.984	(0.028)	***	1.141	(0.022)	***
IPCC	0.726	(0.022)	***	0.691	(0.030)	***	0.745	(0.024)	***
IPCD	0.498	(0.046)	***	0.451	(0.062)	***	0.379	(0.050)	***
IPCE	0.535	(0.032)	***	0.471	(0.045)	***	0.595	(0.035)	***
IPCF	0.526	(0.024)	***	0.493	(0.033)	***	0.501	(0.027)	***
IPCG	0.827	(0.021)	***	0.682	(0.029)	***	0.861	(0.023)	***
IPCH	0.735	(0.023)	***	0.629	(0.031)	***	0.719	(0.025)	***
d_2002	0.001	(0.033)		0.076	(0.049)		0.004	(0.037)	
d_2003	0.000	(0.032)		0.092	(0.048)	*	0.017	(0.036)	
d_2004	0.002	(0.032)		0.100	(0.048)	**	0.048	(0.036)	
d_2005	0.036	(0.032)		0.186	(0.047)	***	0.058	(0.036)	
d_2006	−0.030	(0.033)		0.159	(0.048)	***	−0.003	(0.037)	
d_2007	−0.053	(0.034)		0.192	(0.048)	***	−0.007	(0.037)	
d_2008	0.001	(0.034)		0.281	(0.048)	***	0.094	(0.038)	**
d_2009	−0.083	(0.036)	**	0.287	(0.050)	***	0.029	(0.040)	
d_2010	−0.128	(0.039)	***	0.252	(0.054)	***	0.007	(0.042)	
d_2011	−0.129	(0.039)	***	0.231	(0.053)	***	−0.012	(0.043)	
d_2012	−0.411	(0.042)	***	−0.113	(0.058)	*	−0.310	(0.046)	***
_cons	−0.001	(0.046)		−0.279	(0.069)	***	−1.020	(0.037)	***

Standard errors in parentheses, ***: 1%, **: 5%, *: 10% significant

Some firms have been dropped because of all zero outcomes

Conditional FE negative binomial regression (xtnbreg)

	(4)			(5)			(6)		
Dependent var	fwd_cit			coappl			coinv		
Num obs.	25,776			21,228			29,640		
Num firms	2,148			1,769			2,470		
Obs per firm	12			12			12		
Wald chi2(23)	15,781			6,104			23,716		
Log likelihood	−24,935			−12,772			−30,825		
certify	0.081	(0.035)	**	0.110	(0.042)	***	0.134	(0.027)	***
principal	0.065	(0.056)		−0.030	(0.070)		0.038	(0.043)	
non_pr	−0.139	(0.095)		−0.048	(0.113)		−0.132	(0.073)	*
IPCA	0.724	(0.031)	***	0.755	(0.041)	***	0.706	(0.026)	***
IPCB	1.261	(0.027)	***	1.052	(0.034)	***	1.315	(0.023)	***
IPCC	0.897	(0.029)	***	1.105	(0.038)	***	0.864	(0.025)	***
IPCD	0.319	(0.060)	***	0.750	(0.081)	***	0.451	(0.050)	***
IPCE	0.526	(0.044)	***	0.642	(0.058)	***	0.574	(0.035)	***
IPCF	0.558	(0.032)	***	0.553	(0.044)	***	0.558	(0.027)	***
IPCG	0.912	(0.028)	***	0.973	(0.036)	***	0.951	(0.024)	***
IPCH	0.746	(0.030)	***	0.841	(0.039)	***	0.751	(0.026)	***
d_2002	0.001	(0.042)		0.082	(0.060)		0.011	(0.038)	
d_2003	0.004	(0.042)		0.129	(0.059)	**	0.066	(0.037)	*
d_2004	−0.019	(0.042)		0.142	(0.059)	**	0.069	(0.037)	*
d_2005	−0.036	(0.042)		0.143	(0.059)	**	0.107	(0.037)	***
d_2006	−0.190	(0.044)	***	0.077	(0.061)		0.042	(0.038)	
d_2007	−0.250	(0.045)	***	0.037	(0.061)		0.039	(0.038)	
d_2008	−0.261	(0.046)	***	0.222	(0.061)	***	0.149	(0.039)	***
d_2009	−0.419	(0.049)	***	0.097	(0.065)		0.056	(0.041)	
d_2010	−0.597	(0.054)	***	0.057	(0.070)		0.031	(0.043)	
d_2011	−0.874	(0.058)	***	0.085	(0.069)		0.052	(0.043)	
d_2012	−1.489	(0.069)	***	−0.145	(0.073)	**	−0.239	(0.046)	***
_cons	−1.899	(0.038)	***	−1.932	(0.058)	***	−1.675	(0.034)	***

Standard errors in parentheses, ***: 1%, **: 5%, *: 10% significant

Some firms have been dropped because of all zero outcomes