2014 Proceedings of PICMET '14: Infrastructure and Service Integration.

An Examination of the Output Additionality of Japan's R&D Subsidies for Small and Midsized Enterprises[1]

Shigenori Hata
Research Institute of Economy, Trade and Industry, Tokyo, Japan

Abstract--**This study examines the output additionality of R&D subsidies for small and midsized enterprises in Japan. Results show that there are no significant differences in business performance indicators, such as return on assets, sales growth rate, and employment growth rate before and after participating in the subsidy program. As for the innovative activity indicators, there are no significant differences in such variables as R&D expenditure and R&D expenditure-to-asset ratio (RDA) either.**

While R&D expenditure shows no significance change, the number of patent applications reduced significantly: patent productivity declined regardless of the subsidies.

I. INTRODUCTION

Effective and efficient public-sponsored research and development (R&D) programs are one of the policy priorities for developed countries that are struggling with fiscal reconstruction while pursuing economic growth. This is particularly true for Japan, which is facing serious budget constraints due to a huge national debt and economic slowdown.

Recently, great attention has been paid to small and midsized enterprises (SMEs) in the innovation policy arena, because of their role as economic innovators. Although the focus has been on R&D in SMEs, the examination of output additionality of R&D subsidies for SMEs is rarely conducted in Japan.

Against that background, this paper examines the output additionality of government R&D subsidies for SMEs in Japan. The paper is structured as follows. Section 2 reviews the previous literature and presents the hypothesis to be examined; Sections 3 and 4 briefly introduce the government R&D subsidy program and the dataset, respectively; finally, Sections 5 and 6 contain a discussion of the results and a presentation of the main conclusion.

II. PREVIOUS RESEARCH AND PRESENTATION OF HYPOTHESIS

There are many studies on the effects of government-sponsored R&D programs. As [6] reviews, it is common for a comparison to be made between publicly supported groups and control groups to examine the differences in their performances. Reference [1] examined the effects of the EU's EUREKA program and concluded that the return on assets for those companies participating in the program significantly increased after completion.

Reference [2] also examined, from a range of perspectives, the effects of a specific government-sponsored commercial R&D program in Flanders. They concluded that (i) policies were not subject to full crowding out; (ii) effects were stable over time; (iii) receiving subsidies from other sources in addition to the program under evaluation did not reduce the magnitude of the effects; and (iv) receiving grants repeatedly did not reduce the magnitude of the effects either.

In the case of the Japanese firms, [4] examined the impact of public subsidies on R&D activities of firms using microdata from large Japanese manufacturing firms between 1995 and 2005. Using propensity score matching and difference-in-differences techniques to examine the causal effects of public R&D subsidies, they concluded that the level of a firm's own R&D investment was not affected by public R&D subsidies, but that public R&D subsidies did encourage a firm's R&D activity in specific fields, such as the environment and information and communications technology.

Reference [11] examined the effect of the US Small Business Innovative Research (SBIR) Program, using individual data from participating companies. It highlighted that no statistically significant results were obtained with regard to whether R&D subsidies increased R&D expenditure of participating companies, and that companies with more employees received more in SBIR subsidies. The important observation from this study was that SBIR subsidies tended to crowd out companies' own R&D expenditure.

Much of the previous research focuses on whether subsidies crowd out a firm's own R&D expenditure; however, one of the main objectives of R&D subsidies for SMEs is to upgrade their R&D capability. Therefore, this study analyzes changes in R&D performance of SMEs using detailed individual firm-level data. Consequently, the hypothesis to be tested is whether the government R&D subsidy program for SMEs in Japan produces output additionality in the business and R&D activities of recipients.

III. SMALL AND VENTURE FIRMS TECHNOLOGY SUPPORT PROGRAM (SVTP)

This study considers the Small and Venture Firms Technology Support Program (SVTP) as an example of a government R&D subsidy program. SVTP is a 5-year program run by Japan's Ministry of Economy, Trade and Industry (METI) to promote research, development, and commercialization of the output of R&D from small and venture firms.

Specifically, METI and its affiliate agency provide both financial support, of up to two-thirds of the total expenditure for individual R&D projects of firms, and consultative support for the commercialization of the results. The upper

[1] This research is part of the "Technology and Innovation Program" at the Research Institute of Economy, Trade and Industry (RIETI).

limit for the subsidy varies according the time of operation; i.e. 15 million Japanese Yen (JPY) in 2004; 45 million JPY in each year between 2005 and 2007; and 20 million JPY in 2008.

In total, 634 firms have received 12.8 billion JPY in subsidies, with subsidies being granted only once.

These subsidies supported the following number of firms in each of the major technology categories: 87 firms in life sciences; 87 firms in information and communications technology; 43 firms in nanotechnology; 88 firms in environmental technology; 216 firms in production technology; 77 firms in energy technology; and 36 firms in other technologies.

An important characteristic of this program is to provide not only a subsidy for R&D but also a consultation service for the commercialization of the technology. This is in accordance with a growing trend in the innovation policy arena, which intends to promote the R&D capability in SMEs by strengthening their networks with external organizations, such as universities.

According to METI's ex-post evaluation report on SVTP, the recipient firms have applied for a total of 252 patents, based on the R&D activities sponsored by the program [8]. This report also shows that 73.3% of the subsidized projects were successful and that 29.4% were commercialized within 2 years of completion; such a low commercialization rate is mainly attributed to the SMEs' lack of marketing abilities and internal finance. However, an analysis of the business performance of the recipient firms is beyond the scope of this report.

IV. DATA SET AND ANALYSIS

To observe behavioral changes in the R&D activities of SMEs, detailed information at a firm level is necessary. This data set was constructed by matching three data sources: the Basic Survey of Japanese Business Structure and Activities (SBA); a list of recipient firms for SVTP subsidies; and the Institute of Intellectual Property (IIP) patent database.

SBA is a firm-level survey launched in 1992 and conducted every year since 1995 by METI. In 2013, 37,523 companies were surveyed, of which 32,091 responded, resulting in a response rate of 85.8%. The survey analyzes business activity indicators, such as total sales, total added value, and total number of employees, as well as innovative activity indicators, such as R&D expenditure and number of patents held, at the end of Japan's fiscal year in March every year. The companies included are selected according to the following criteria. (i) Those having offices or facilities engaged in mining (39 companies in 2013); electricity and gas supply (130); manufacturing (13,145); wholesale trade (5,806); retail trade (3,609); credit card and installment finance (85); eating and drinking services (604); information services (2,453); goods rental and leasing (excluding rental business, 296); scientific research, professional, and technical services (597); living-related and personal services (2,033). (ii) Those having 50 or more employees and a capital of 30 million and above JPY.

The advantage of SBA is that detailed activity indicators for the firms surveyed are available over two decades, from 1992 to the present. As a result, by utilizing each firm's data, longitudinal data can be constructed to analyze the behavior of those individual firms.

The IIP Patent Database is a comprehensive database of patent applications filed with the Japan Patent Office, consisting of a patent application file (9,027,486 records), patent registration file (2,618,699 records), applicant file (626,708 records), rights-holder file (204,622 records), and citation information file (5,318,225 records) [3].

The data trimming process employed in this study involved the following stages: first, manufacturing firms with employees equal to or less than the maximum number of employees in SVTP recipient firms were selected from the SBA data; and second, the list of SVTP recipient firms was matched with the trimmed SBA data. The final samples of recipient and non-recipient firms became 96 and 20,552, respectively. Although, 634 firms received SVTP subsidies, this process of matching SVTP recipient with firms surveyed under SBA resulted in a recipient firms' sample of only 96. The reason for this significant reduction is because SBA only surveys firms with more than 50 employees, while SVTP recipient firms are relatively small in size. The third and final stage in the data trimming process was that for each of the 96 recipient firms, patent application data for the period from 1994 to 2011 were extracted from the IIP Patent Database.

In Table 1, the most relevant features of the samples are highlighted, indicating that SVTP recipient firms, on an average, have lower sales but a larger number of employees, R&D expenditure-to-asset ratio (RDA), and number of patents held as compared to non-recipient firms. In Table 2, it should be noted that the largest proportion of SVTP recipient firms fall in the production machinery category.

TABLE 1. SUMMARY STATISTICS

		Recipient firms	Non-recipient firms	Overall
Sales(in Mil. JPY)	sample size	N = 976	N = 148674	N = 149650
		n = 96	n = 20552	n = 20648
	Mean	5426.774	8215.478	8197.29
	Standard Deviation	6042.216	24642.03	24567.41
	Minimum	339	25	25
	Maximum	16241	3138867	3138867
Number of employees	sample size	N = 976	N = 148674	N = 149650
		n = 96	n = 20552	n = 20648
	Mean	207.3023	206.584	206.5887
	Standard Deviation	160.7164	190.5638	190.3839
	Minimum	50	1	1
	Maximum	1080	1080	180
Return over sales	sample size	N = 976	N = 148674	N = 149650
		n = 96	n = 20552	n = 20648
	Mean	0.027471	0.0264957	0.0265021
	Standard Deviation	0.0635582	0.218301	0.2176485
	Minimum	−0.717033	−38.77778	−38.77778
	Maximum	0.2022059	7.523683	7.523683
R&D expenditure to Asset ratio	sample size	N = 764	N = 87633	N = 88397
		n = 91	n = 17775	n = 17866
	Mean	0.0151281	0.0135359	0.0135497
	Standard Deviation	0.0178536	0.0292704	0.0291911
	Minimum	0	0	0
	Maximum	0.1156161	2.622265	2.622265
Number of patents held	sample size	N = 682	N = 77740	N = 78422
	year	n = 89	n = 17161	n = 17250
	Mean	24.36657	22.4566	22.47321
	Standard Deviation	46.54186	77.80187	77.58435
	Minimum	0	0	0
	Maximum	387	3328	3328

TABLE 2. SAMPLE DISTRIBUTION BY INDUSTRY CATEGORY (OBSERVATIONS)

		Non-recipient firms	Recipient firms	Total
	FOOD	13,421	40	13,461
	BEVERAGES,TOBACCO AND FEED	1,984	3	1,987
	TEXTILE MILL PRODUCTS	3,520	22	3,542
	LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE	7,711	11	7,722
	FURNITURE AND FIXTURES	2,088	0	2,088
	PULP, PAPER AND PAPER PRODUCTS	3,073	12	3,085
	PRINTING AND ALLIED INDUSTRIES	4,058	2	4,060
	CHEMICAL AND ALLIED PRODUCTS	4,564	8	4,572
	PETROLEUM AND COAL PRODUCTS	5,210	15	5,225
	PLASTIC PRODUCTS, EXCEPT OTHERWISE CLASSIFIED	2,009	1	2,010
	RUBBER PRODUCTS	3,774	5	3,779
	LEATHER TANNING, LEATHER PRODUCTS AND FUR SKINS	4,383	14	4,397
	CERAMIC, STONE AND CLAY PRODUCTS	2,166	20	2,186
	IRON AND STEEL	4,570	27	4,597
	NON-FERROUS METALS AND PRODUCTS	4,221	13	4,234
	MANUFACTURE OF FABRICATED METAL PRODUCTS	5,905	54	5,959
	GENERAL-PURPOSE MACHINERY	10,277	88	10,365
	PRODUCTION MACHINERY	14,387	215	14,602
	BUSINESS ORIENTED MACHINERY	8,067	70	8,137
	ELECTRONIC PARTS, DEVICES AND ELECTRONIC CIRCUITS	5,949	42	5,991
	ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES	10,526	118	10,644
	INFORMATION AND COMMUNICAION ELECTRONICS EQUIPMENT	14,855	112	14,967
	TRASPORTATION EQUIPMENT	10,587	76	10,663
	MISCELLANEOUS	1,369	8	1,377
		148,674	976	149,650

V. RESULTS AND DISCUSSIONS

To examine the output additionality of SVTP, a comparison was made of R&D and business performance before and after participating in the program. To observe productivity in patent activity, two indicators were introduced: (i) the number of patent applications divided by the number of R&D employees; and (ii) the number of patent applications divided by the R&D expenditure. It should be noted that a lead time exists in patent activities and that applications in a specific year do not necessarily reflect the R&D expenditure in the same year. Previously, reference[9] established that it takes about 2 years for a firm to submit a patent application after initiating the research .

Table 3 shows the changes in the R&D and business performance of the recipient firms before and after participating in the program. By observing the business performance indicators, return on assets, sales growth rate, and employment growth rate show no significant changes.

With regard to R&D performance, there are also no significant differences in variables such as R&D expenditure and RDA.

While the number of patent applications relative to R&D employees showed no significant difference either, the number of patent applications relative to R&D expenditure reduced significantly. This decline is attributable to the fact that the number of patent applications reduced significantly despite R&D expenditure remaining the same.

This decline in patent applications may also reflect the reduction in the number of R&D employees, since patent productivity based on the number of R&D employees shows no significant change. Presumably, one of the factors for the reduction in R&D employees by recipient firms was because they downsized their R&D sections in the face of the 2008 economic global crisis.

Since the matching of patent applications data and SBA for non-recipient firms is still in progress, the general trend in patent applications by non-recipient firms cannot be determined. The Japan Patent Office's annual report, however, points out that the number of patent applications in Japan reached its peak in 2000 (387,000 applications) and that there has been a slight downward turn up in 2011. It also shows that there was a decline of about 11% in patent applications in Japan from 2008 to 2009, mainly due to the global economic crisis [5].

As shown in Table 4, it is interesting that RDA for the non-recipient group has increased significantly at the 1% level between the periods 1994-2003 and 2004-2011, whereas RDA for the recipient group showed no significant change before and after SVTP participation (Table 3).

This implies that some factors have influenced the behaviors of only the non-recipient group. One presumable external factor is the strengthening of R&D tax credits in 2003, whereby a firm could claim an R&D tax credit of 12% on volume for SMEs and 8–10% for large firms, depending on the level of their R&D activity, therefore, reducing their tax liability by up to 30%. This change seems to have been a considerable incentive to R&D in SMEs, since previously only 5% on incremental R&D (taking an average R&D over the previous 3 years as the baseline) could be deducted from the corporate tax payable. It is thought that the non-recipient group may have changed their attitude towards R&D with this new R&D tax credit scheme.

However, the effect of this new scheme is controversial. On one hand, [10] examined whether the 2003 tax credit scheme for gross R&D induced additional R&D investment in Japanese firms, using firm-level data. They concluded that those firms receiving the new tax credit did not significantly increase their R&D expenditure compared to those who were not in receipt. On the other hand, [7] concluded that R&D tax credits did induce an increase in R&D expenditures of SMEs.

The other interesting fact is that RDA for the recipient group did not significantly change despite the new scheme. One possible explanation is that RDA for this group was already high before the new scheme started, and therefore its effect was marginal.

TABLE 3. CHANGES BEFORE AND AFTER PARTICIPATING SVTP FOR RECIPIENT FIRMS

Variable		Mean	Std. Dev.	Min	Max	Observations
R&D expenditure(mil. Yen)	before subsidized	63.94194	119.654	0	789	N = 620 (n= 83)
	after subsidized	62.60674	101.4124	0	801	N = 356 (n= 83)
	Statistical t (p-value)	*0.1852*	*0.8531*			
R&D expenditure - to-asset ratio	before subsidized	0.0129332	0.0174654	0	0.1075949	N = 620 (n= 83)
	after subsidized	0.0120282	0.0166214	0	0.1156161	N = 356 (n= 83)
	Statistical t (p-value)	*0.8037*	*0.4218*			
Number of patent applications	before subsidized	4.932258	15.55163	0	165	N = 620 (n= 83)
	after subsidized	2.533708	12.01766	0	128	N = 356 (n= 83)
	Statistical t (p-value)	*2.6888*	*0.0073*			
Patent applications/(Number of R&D employees)	before subsidized	0.4847982	2.292826	0	39	N = 425 (n= 66)
	after subsidized	0.3598913	1.966314	0	24.25	N = 217 (n= 53)
	Statistical t (p-value)	*0.7189*	*0.4725*			
Patent applications/(R&D expenditure)	before subsidized	0.104407	0.3462684	0	5	N = 448 (n= 80)
	after subsidized	0.0317912	0.1019271	0	1	N = 275 (n= 71)
	Statistical t (p-value)	*4.1551*	*0*			
Number of R&D employees	before subsidized	9.609677	17.17935	0	146	N = 620 (n= 83)
	after subsidized	7.699438	14.15994	0	134	N = 356 (n= 83)
	Statistical t (p-value)	*1.8738*	*0.0613*			
Return on sales	before subsidized	0.0295651	0.0514062	-0.2848606	0.2017861	N = 620 (n= 83)
	after subsidized	0.023824	0.0804114	-0.717033	0.2022059	N = 356 (n= 83)
	Statistical t (p-value)	*1.2123*	*0.2259*			
Sales growth rate	before subsidized	1.027824	0.2449534	0.2376112	3.963636	N = 510 (n= 78)
	after subsidized	1.032284	0.4594534	0.0470849	8.126551	N = 323 (n= 77)
	Statistical t (p-value)	*-0.1606*	*0.8725*			
Employment growth rate	before subsidized	1.004378	0.1084189	0.6766667	1.754386	N = 501 (n= 78)
	after subsidized	1.003089	0.1041266	0.5980861	1.585586	N = 316 (n= 76)
	Statistical t (p-value)	*0.1695*	*0.8655*			

TABLE 4. R&D EXPENDITURE TO ASSET RATIO OF NON-RECIPIENT FIRMS BY PERIOD

		Obsevations	Mean	Standard Error	Standard deviation
Non-recipient firms	overall	87633	0.0135359	0.0000989	0.0292704
	2004-2011	36363	0.0171247	0.0001811	0.0345322
	1994-2003	51270	0.0109906	0.0001085	0.0245571
	Statistical t (p-value)	*-29.0601*	*(0.0000)*		

VI. CONCLUSION

This study examined the output additionality of the Small and Venture Firms Technology Program (SVTP), which is METI's R&D subsidy program for SMEs. The main findings of this study are presented as follows.

Business performance indicators, such as return on assets, sales growth rate, and employment growth rate, show no significant changes before and after participating in the program. In addition, there are no significant differences in variables such as R&D expenditure and R&D expenditure-to-asset ratio (RDA).

While R&D expenditure showed no significant change, the number of patent applications reduced significantly. This may be attributable to the reduction in the number of R&D employees, as a result of recipient firms downsizing their R&D sections in the face of the global economic crisis of 2008.

While there was no significant difference in the recipient group's RDA before and after SVTP participation, the RDA for the non-recipient group made a significant increase over the same period. A change in the R&D tax credit scheme in 2003 may have influenced the behavior of non-recipient firms.

This study is based on a straightforward statistical approach, comparing changes in R&D and business activities of recipient firms before and after participating in the subsidy program. To analyze output additionality more precisely, however, techniques such as propensity score matching should be applied to address the selection bias involved in the current analysis. In addition, a more sophisticated econometric method should be applied to eliminate the effects of external factors such as global economic recessions, which tend to have negative impacts on firms' innovative activities.

REFERENCES

[1] Bayona-Saez,C.,and T.Garcia-Marco, “Assessing the effectiveness of the EUREKA Program,” *Research Policy,* vol.39, pp.1375-1386, 2010.
[2] Czarnitzki,D., and C.Lopes-Bento, “Value for money? New microeconometric evidence on public R&D grants in Flanders,” *Research Policy* 42(2013), pp.76-89,2013.
[3] Goto,A., K.Motohashi, “Construction of a Japanese Patent Database and a first look at Japanese patenting activities,” *Research Policy* 36 pp.1431-1442, 2007.
[4] Ito,B., and S.Nakano, “The impact of public R&D subsidies on firm’s R&D activities: evidence from Japanese firm-level data” *ESRI Discussion Paper Series* No.222 (in Japanese),2009.
[5] Japan Patent Office annual report 2013.
[6] Klette,T.J.,J.Moen and Z.Griliches, “Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies,” *Research policy*, vol.29, pp. 471-495,2000.
[7] Kobayashi, Y., “Effect of R&D Tax Credits for Small and Medium-sized Enterprises in Japan: Evidence from firm-level data,” *RIETI Discussion Paper Series* 11-E-066,2011.
[8] Ministry of Economy, Trade and Industry of Japan, The ex-post evaluation report on Small and Venture firms’ Technology Program (SVTP) (in Japanese),2011.
[9] Nagaoka,S., N.Tsukada, “Innovation Process in Japan: Findings from the RIETI Inventors Survey,” *RIETI Discussion Paper Series*, 07-j-046,2007.
[10] Onishi,K., A.Nagata, “Does tax credit for R&D induce additional R&D investment? Analysis on the effects of gross R&D credit in Japan,” *Journal of Science Policy and Research Management* 24, pp.400-412(in Japanese),2009.
[11] Wallsten,S.J., “The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program,” *Rand Journal of Economics,* vol.23 (1), pp. 82-100,2000.