Evaluation of Small Business Innovation Research Programs in Japan

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Abstract

Subsidizing small high-technology firms is now considered to be important in stimulating economies throughout the world. This is because fast growing small firms create new markets and jobs. The Small Business Innovation Research (SBIR) program has played an important role in the United States in subsidization providing two billion dollars every year. Japan started its own SBIR program inspired by that in the United States.

This paper examines the direct effects of Japan's SBIR program through

the attributes of firms. First, we compared the changes in sales, employment, and the number of patents between SBIR awardees and matching firms. However, SBIR awardees did not demonstrate better performance in sales or employment. Therefore, it seems that the direct effect of Japan's SBIR program has not produced positive results. However, it did increase the number of patents. Second, we examined the overall results by using regression models. Even with control variables, these results were unchanged. Therefore, we concluded that the results were robust.

Keywords

Small business, Research policy, Innovation, SBIR, Japan

JEL codes

O2, O3

1 Introduction

Japan has suffered from a serious long-term recession that began in 1991 and the Japanese government has tried, by various means, to solve the problem. One way has been to subsidize small, high-technology firms, which are now considered to play important roles in stimulating economies throughout the world [1]. This is because fast growing small firms have created new markets and jobs [2].

There are two rationales to justify such subsidization. First, the social benefits

are greater than the expenditure that firms spent on R&D [3]. Second, private investors can tap into information that subsidized companies are authorized in the sense of promising technology. This can be rephrased as an information gap between firms and investors [4].

The Small Business Innovation Research (SBIR) program that was started in 1982 in the United States has played an important role in subsidization providing two billion dollars every year. The program requires (currently eleven) federal agencies to set aside (also currently) 2.5 percent of their extramural R&D funds for SBIR. The program consists of three phases and only winners can proceed to the next phase. The program is the largest innovation program in the U.S. [7] and there is no doubt about its importance. Japan started its own SBIR program in 1999 inspired by that in the United States.

The cost-effectiveness of all policies should be monitored but this is difficult to do for many of them because the effect spreads into society, making the problem more complex. Even so, Lerner studied firms which won awards of the U.S. SBIR program and demonstrated that the firms grew significantly faster in comparison with other matched firms and attracted venture financing [5]. Although Japan's SBIR program was studied by Eshima [6], his study was limited compared to the coverage of analyses done by Lerner and his analyses had bias that led readers to a different conclusion from one in this paper. The details on the problems will be

explained later.

We analyzed Japan's SBIR program by introducing data obtained from firms. The analyses followed those of Lerner and also included other data and perspectives to enable characteristics specific to Japan to be investigated. More concretely, we assessed the growth of firms which won awards of the SBIR program from 2006 to 2010. The analyses were done by comparing of matching firms that were chosen because they closely resembled the awardees. Growth was measured by sales, employees, and the number of patents. The analyses had two clear limitations. The first one was that they did not include social welfare, which was the eventual goal of the policies. This means we only found the primary effect of the subsidies. The second limitation was that the analyses could not provide alternative policies because we only studied one policy.

This paper is organized as follows. A brief explanation of the SBIR program is given in Section 2. Section 3 explains how we constructed the data we used in the analyses. Section 4 discusses empirical analyses and Section 5 concludes the paper.

2 SBIR programs

2.1 U.S. SBIR program

The United States' Congress enacted the SBIR Development Act in 1982 and established the SBIR program, which mandated that all federal agencies spend more than $100 million to set aside 0.2 percent of their funds for SBIR. Over the next six years, the funds that were set aside grew to 1.25 percent. This act was reauthorized in 1992, as the Small Business Research and Development Enhancement Act. At this time, the funds that were set aside were doubled to 2.5 percent [7]. Congress passed numerous extensions, the most recent of which extended the act through 2017. Also, the current funds that were set aside were set to 2.8 percent.

Eleven federal agencies have been participating in the program and they have individual responsibility for the program. Therefore, they have been subsidizing and conforming to the guidelines set by the SBIR program.

A document published by the Small Business Administration [8] provides current practical information. Here, we present a plain explanation of the process for the program.

The SBIR program has three phases.

- Phase I: This phase is aimed at checking the technical advantages, feasibility,

commercial potential, and the quality of awardee performance prior to support in Phase II. Phase I awards normally do not exceed $150,000 total costs for six months.

- Phase II: The main objective of this phase is to continue and enhance the R&D efforts initiated in Phase I. Only Phase I awardees are eligible for a Phase II award. Phase II awards normally do not exceed $1,000,000 total costs during two years.

- Phase III: This phase, where appropriate, is for small businesses to pursue commercialization objectives resulting from Phase II activities. The SBIR program does not fund Phase III. Some federal agencies promote the introduction of private investments or provide awardees with production contracts for products such as the procurements of agencies.

Eligibility for the SBIR program is mainly assessed as follows.

1. Owned independently and at least 51% by U.S. citizens.

2. No more than 500 employees, including affiliates.

3. Organized for profit and located in the United States

The achievements of the SBIR program are worth admiring. The SBIR program assessment done in 2008 [7] found that it was mainly effective in three areas.

1. Stimulating technological innovation

2. Increasing private sector commercialization of innovations

3. Providing widely distributed support for innovation activities

2.2 Japan's SBIR program

Japan has been in a serious long-term recession since 1991. The Ministry of International Trade and Industry enacted a law in 1999 to facilitate the creation of new businesses that included Japan's SBIR program to break out of the recession and secure more employment opportunities, Apparently, Japan had considered the SBIR program in the U.S. to be successful. Then, the Ministry of Economy, Trade and Industry enacted an act in 2005 to facilitate new business activities by small and medium-sized enterprises that retained the SBIR program in Japan.

Although the program in Japan was naturally quite similar to that in the U.S., there were three considerable differences.

1. Awards by most ministries and agencies do not have phase systems. Only around 5% of awards have phase systems that began in 2007 and 2008.

2. Ministries and agencies mainly supported awardees from finances in their own budget. However, the U.S. program helps awardees to access private investments and procurements by governments.

3. The budget is much smaller. It is approximately one fifth that of the U.S.

Note that Japan has other initiatives for nurturing small high-technology businesses. For example, the New Energy and Industrial Technology Development Organization has a number of their own initiatives other than the SBIR program. This paper only discusses the SBIR program and its effects but naturally does not cover all initiatives for small high-technology businesses.

3 Data

Since we followed Lerner's analyses, we constructed data almost identical to his and added additional data for further discussion. As primary data, we acquired published data from SBIR awardees obtained from the Small and Medium Enterprise Agency. The data included 3,559 SBIR awardees from 1998 to 2010. However, since many firms won more than one award, there were 1,640 firms. Table 1 summarized the number of constructed data. We focused on 507 awardees from 2004 to 2006 to analyze their growth. Even individuals can win awards in Japan unlike the SBIR program in the U.S. We omitted individuals since they were not appropriate to the analyses in this paper. Finally, 301 firms were chosen as awardees from 2004 to 2006. Basically, Japan's SBIR program does not have phase systems, and as phase II started from 2007 with only 5%, we ignored it as was mentioned earlier.

We then constructed matching sets to compare means and percentiles and conducted regression analyses. We selected firms that closely resembled awardees from Teikoku Data Bank (TDB) data, which has one of the most comprehensive data on firms in Japan.

One set was matched on industry and firm size. The TDB data included its own industry code. The middle classification has 91 different codes and we used this to categorize firms. Three hundred one firms in the same classification with the closest sales in 2006 were selected from the TDB data to pair them with 301 awardees.

Another set was matched on geographic location and firm size. The procedure was similar to that for the industry matching set. We used the two digits at the head of the zip code. In the same way, three hundred one firms with the same zip code with the closest sales in 2006 were selected.

The method that was used to construct the data described strictly conform to Lerner's approach. To reveal current problems with the SBIR program in Japan and discuss solutions to these, we added supplemental data to each firm. By employing Institute of Intellectual Property data [9], we could add the number of registered patents that had been applied in each year by firms.

The data construction in Lerner's work included the investigations into acquiring investments by venture capitals. However, we could not do the same thing. This is not because we could not find data, but private investments in Japan such as

venture capitals are extremely rare in the first place. This will be discussed in the later sections.

The sample data are summarized in Table 2. The matching firms resembled the awardees closely in sales. The employments of matching firms were higher than those of the awardees. This is because the definition of a small firm is a firm with less than 300 employees in manufacturing or less in other industries. This limitation lowers the number of employees. Age means the difference between the foundation year and 2006. We can see capital and age have similar values. However, the number of applied patents by awardees are seemingly larger than that by matching firms. This will be discussed in detail later.

4 Empirical analyses

4.1 Overall effect of subsidies

As previously mentioned, this paper focuses on the direct effects of subsidies, and not their social benefits. Even if we had focused on the direct effects, we still have difficulty in estimating them.

First, since people in charge of ministries and agencies may want to show how successful the SBIR program is, they may tend to choose their own favorite firms. This situation may inhibit fair competition. Second, similar to the first perspective,

technological tasks presented by ministries and agencies may only be overcome by some specific firms that are more familiar with the problems than others. Finally, it is critical that subsidies themselves do not help skyrocket R&D in small high-tech firms. This is because the small firms are organized by one key scientist or engineer and other members to help him/her. This means that subsidies cannot help to scale the project up even if they hire more members to help the key person. The most probable scenario here is that awardees just substitute awards for their own budget for R&D and prolong the time for R&D. Bearing in mind the purpose of the SBIR program, this is a crucial concern.

Table 3 lists the overall comparison of growth for awardees and matching firms. We do not see any differences in the change in sales from 2006 to 2011 in panel A. In addition, the t-test to compare means and the Mann-Whitney test to compare medians indicate no significance. Although the t-test in panel B does not indicate significance, the Mann-Whitney test indicated significance and it seems that employment of awardees is slightly better.

If we think of the direct effect of awards, especially their direct commercial effect, the results in panel A mean the SBIR program is disappointing. Although employment is somewhat better for awardees, employment is limited to under 300 for awardees and therefore the natural decrease is modest. Moreover, better employment with equivalent sales make us doubt overall growth because it is not sus-

tainable.

Panel C has the numbers of patents from 2006 to 2011. The panel obviously indicates that awardees acquired more patents. Intellectual property cannot be considered to be direct growth but the awardees demonstrated more possibilities of growth in terms of seeds of commercialization and the results also indicate that the process of choosing awardees is probably sound.

The overall results in panels A and B are different from the SBIR program studied by Lerner. The overall results for the SBIR program in the U.S. were significantly positive.

Comparing situations in two different countries is never easy at any time. However, there is a convincing cause for this. Lerner repeatedly emphasized functions of private investments, which were almost equal to venture capital. He delved into the details on what effect the private investments had and found that the success of awardees was dependent on their ability to attract venture capital [5].

Venture capital under management in the U.S. was worth 267 billion dollars in 2012 [10]. However, that in Japan was worth 1 billion dollars in 2012 [11] [1]. The relative size of Japanese venture capital is 0.003. As we mentioned earlier, the SBIR program in Japan is one hundredth of that in the U.S. This means that the relative size of venture capital in Japan is a thirtieth of that in the U.S. In this situation,

[1]We assume 1 U.S. dollar= 100 Japanese yen.

small firms can only acquire loan from banks or public agencies. This situation is far from the goal of SBIR and can be likened to a rocket without a fuel tank.

As we saw in panel C of Table 3, the awards certainly assisted R&D. Combined with the other results, commercialization assistance, which is the most important part of the program, seemed to have a problem. The SBIR program in the U.S. methodically supports the commercialization of seeds grown by the program [7]. The support includes a committee made up of researchers at universities, national institutes, or those who were finance professionals. In comparison, we could not find any similar support available in Japan as is the case in the U.S. Although it is reasonable to assume that commercialization is the most difficult part of R&D, it seems that Japan has not properly budgeted for commercialization.

As we mentioned in Section 1, Eshima carried out the same overall analyses in Japan [6] and said that SBIR awardees yielded positive results. His work is important as the first attempt toward SBIR analyses in Japan but the analyses seem to have the three problems. First, he made matching sets in a different way from that by Lerner, nevertheless he could. Since he started from Lerner's work, as we did, avoiding comparisons of results without any explanation seems to be unfair. Second, he mentioned he used phase II awardees' data, the same as Lerner had done, but until 2007, the SBIR program in Japan did not have a phase system. Finally, there was no regression analysis that Lerner had done. Regression analysis

is important to see what effect SBIR has by controlling other variables. Therefore, our paper can provide fuller and sounder analyses and comparisons.

4.2 Effect of subsidies controlled by firms' attributes

We discussed previously the overall effect of the SBIR program, we will next delve into more precise analyses by introducing regression analyses. Table 4 lists the variables used in the regression analyses. Most of them have been used in the previous analyses. Table 5 is a correlation matrix for independent/control variables. As we cannot see any strong correlations, we can presumably place them into regression models.

Table 6 summarizes the growth in sales and employment in the regression models. All variables are taken from Table 4. Panels A, B, and C correspond to changes in sales, changes in employment, and the number of patents. Also, these dependent variables are the same as those in overall analyses listed in Table 3. A core independent variable is "Any SBIR award in 2004-2006" and a core control variable is "2006 sales" or "2006 employment." Models with even numbers also have other control variables of age, location, and industry.

Panels A and B strongly indicate that SBIR awardees could not increase in sales or employment even after controls by sales, employment, and other control variables were introduced. This is a backup of the overall analyses. The results in Panel

C also support the overall analyses. Winning SBIR awards positively affects the acquisition of registered patents. Even in model (10) which was strongly controlled, SBIR awards demonstrated significance.

5 Conclusion

We examined the direct effects of the SBIR program in Japan through firms' attributes. First, we compared changes in sales, employment, and the number of patents between SBIR awardees and matching firms. The SBIR awardees did not perform better in sales or employment. Therefore, it seems that the direct effects of the SBIR program are not positive. However, the awardees performed better in the number of patents. Second, we examined the overall results by using regression models. Even with control variables, these results were sustained, which means they are robust.

In closing, we need to suggest some ideas to improve the program. First, it is most important to rigorously assess the program. Although most countries have recognized that small businesses are the key to economic growth, and where Japan is no exception, its ministries and agencies have not been sincere at all. Even when budgets are not fully available, it is easy to "set aside" some of the budget to assess the program. Normally, the work discussed in this paper should be formally

conducted. Second, appropriate exits for awardees are not clear. We could not find whether ministries and agencies had strategies to create new markets after successful R&D projects were completed by awardees. It could even be said that the program has just been prolonging the life of small firms. Since we could learn from practices in the U.S. of assessment and situations where small firms in the U.S. could readily create seeds of commercialization, the ideas described here can probably be carry out.

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Table 1: Construction of sample of SBIR awardees and matching firms: Number of samples we constructed. Basic data on 301 SBIR awardees. For each awardee, we chose a firm that was industry-matched and closest in sales and a firm that was location-matched and closest in sales. TDB means Teikoku Data Bank data, which includes data on Japanese firms. Firms available in analyses means firms with valid data for regression analyses.

Firms	No. of firms
SBIR awardees that received one or more awards	
in 1998-2010 (including individuals)	1,640
in 2004-2006 (including individuals)	507
in 2004-2006 having valid data in TDB (firms)	301
Matching firms selected from TDB paired with SBIR awardees	
Industry-matched and closest sales	301
Location-matched and closest sales	301

Table 2: Comparison of SBIR awardees and matching firms: Sample data are compared to check validity of matching firms. Units for sales and capital are in thousands of yen. Matching firms were selected according to 2006 sales, industries, and locations and seem well controlled.

	Mean	SD	Minimum	Maximum
SBIR awardees:				
2006 sales	2,446,647	4,510,382	721	31,567,815
2006 employment	82	129.7	2	1,003
2006 capital	198,767	781,359	3,000	96,653,241
2006 age	38.78	25.5	2	134
No. of patents applied for in 2004-2006	4.9	12.8	0	182
No. of patents applied for in records	22.1	58.2	0	678
Matching firms:				
2006 sales	2,444,274	4,503,626	900	31,818,825
2006 employment	1,155	26,533.6	1	650,000
2006 capital	147,300	880,616	2,500	18,078,848
2006 age	41.48	24.5	2	134
No. of patents applied for in 2004-2006	1.1	6.2	0	85
No. of patents applied for in records	7.2	42.0	0	690

Table 3: Growth of SBIR awardees and matching firms: Changes in sales indicate no differences between SBIR awardees and matching firms. Differences in changes in employment are significant with median. Since data do not seem to have a normal distribution, significance is more reliable than that with mean. Differences in numbers of patents are significant. Three hundred one observations were made for SBIR awardees and 602 for matching firms.

	SBIR awardees	Matching firms	*p*-value of comparison
A. Change in sales, 2006-2011:			
Mean	-197,412	-100,976	
75th percentile	92,054	62,549	
Median	-27,770	-29,891	
25th percentile	-270,350	-253,208	
SE	113,783.3	10,9526.8	
p-value of t test			0.54
p-value of Mann-Whitney test			0.63
B. Change in employment, 2006-2011:			
Mean	-2.1	-1,094	
75th percentile	9.0	4.0	
Median	0	0	
25th percentile	-4.0	-4.0	
SE	2.2	1,090.5	
p-value of t test			0.31
p-value of Mann-Whitney test			0.01
C. No. of patents, 2006-2011:			
Mean	2.6	0.7	
75th percentile	3.0	0	
Median	1.0	0	
25th percentile	0	0	
SE	0.38	0.19	
p-value of t test			0.00
p-value of Mann-Whitney test			0.00

Table 4: Variables used in regression analyses: Table lists variables used in regression analyses in this paper.

Dependent variable	
Change in sales	Change in sales from 2006 to 2011
% Change in sales	% of change in sales from 2006 to 2011
Change in employment	Change in number of employee from 2006 to 2011
% Change in employment	% of change in number of employee from 2006 to 2011
Number of patents	Number of patents during period from 2006 to 2011
Independent/control variables	
Any SBIR award in 2004-2006	Dummy variable that is set to one if a firm is given at least one award in the period from 2004 to 2006. In other cases, it is set to zero.
2006 sales	Sales in 2006
2006 employment	Number of employee in 2006
Age	Difference between foundation year and 2006

Table 5: Correlation matrix for control and independent variables used in regressions: There are no large correlations between them.

	(1)	(2)	(3)	(4)	(5)
(1) 2006 sales	1.00	-0.01	0.17	0.22	0.00
(2) 2006 employment		1.00	0.00	0.04	-0.02
(3) Capital			1.00	-0.06	0.03
(4) Age				1.00	-0.05
(5) Any SBIR award in 2004-2006					1.00

Table 6: Results of regression analyses: Dependent variables are changes in sales and employment between 2006 and 2011 and the number of patents from 2006 to 2011. Models (2), (4), (6), (8), and (10) include locations and industries as control variables. Since they are categorical data, they are not listed in the tables. Significance signs are *** for p<0.001, ** for p<0.01, * for p<0.05, and . for p<0.1

A. OLS regressions with change and percentage change in sales as dependent variables

Dependent variables	Change in sales			% Change in sales	
Model number	(1)		(2)	(3)	(4)
Any SBIR award in 2004-2006	-9.5e+04		-2.2e-02	-4.4e-08	2.0e-08
2006 sales	-8.4e-02	***	-1.6e+05	7.1e-01	4.4e-01
Age			1.7e+02		-1.9e-02

B. OLS regressions with change and percentage change in employment as dependent variables

Dependent variables	Change in employment				% Change in employment	
Model number	(5)		(6)		(7)	(8)
Any SBIR award in 2004-2006	1.1e+01		1.1e+01		1.1e-02	-6.9e-04
2006 employment	-1.0e-00	***	-1.0e-00	***	-1.7e-06	-1.3e-06
Age			1.2e+00	***		-1.4e-03

C. OLS regressions with number of patents as dependent variables

Dependent variables	Number of patents			
Model number	(9)		(10)	
Any SBIR award in 2004-2006	1.9e+00	***	1.4e+00	***
2006 sales	3.0e-07	***	3.4e-07	***
Age			-1.5e-02	.