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KOBAYASHI Yohei
RIETI

The Research Institute of Economy, Trade and Industry
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Effect of R&D Tax Credits for Small and Medium-sized Enterprises in Japan: Evidence from firm-level data

KOBAYASHI Yohei *
Research Institute of Economy, Trade and Industry

Abstract

Although numerous studies have evaluated the effect of tax credits on R&D, many have neglected the problem of selection bias. Furthermore, empirical studies have found that Japan's total factor productivity (TFP) growth has slowed since the 1990s, and Kim et al. (2010) have attributed this slowdown partly to low R&D expenditures among small and medium-sized enterprises (SME). Evidence suggests that enhancing R&D among small firms is essential for Japan's economic growth. This paper estimates the effect of R&D tax credits for SMEs using firm-level micro data from "The 2009 Basic Survey of Small and Medium Enterprises." We use the propensity score method introduced by Rubin (1974), in which recipients of tax credits are matched with the most similar non-recipients. Empirical results show that R&D tax credits induce an increase in SMEs' R&D expenditures. Moreover, we find that the effect of R&D tax credits on liquidity-constrained firms is much greater than on firms without liquidity constraints.

Keywords: R&D tax credits, small and medium-sized enterprises, and propensity score matching.
JEL classification: H25; H32; K34; O32; O38

The data used in this paper is micro data from "The 2009 Basic Survey on Small and Medium Enterprises" which is conducted by the Small and Medium Enterprise Agency of the Ministry of Economy, Trade and Industry. This research is a part of the project on "Evaluation of Corporate Tax" at the Research Institute of Economy, Trade and Industry (RIETI).

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* Consulting Fellow, RIETI, E-mail kobayashi-yohei@meti.go.jp. COE Visiting Young Scholar, Hitotsubashi University.

1 Introduction

In modern theories of economic growth, research and development (R&D) plays a major role in sustainable growth. Technological progress is important, especially in Japan, as it is facing a rapidly decreasing population. However, R&D has spillover effects on other firms, and its social return is higher than its private return. In other words, since R&D has characteristics of a public good, Japan's level of R&D expenditures is below optimum.

Many governments offer tax credits or direct grants to foster private sector R&D. Tax credits are often favored because they are neutral with respect to industry and the nature of firm. Compared to direct grants, they have the advantage of potentially minimizing discretionary decisions by government.

Numerous studies have evaluated the impact of tax credits on R&D. Hall and van Reenen (2000) comprehensively summarize the related literature and conclude that a $1 tax credit for R&D induces about $1 of additional R&D expenditures. Although estimating the effects of R&D tax credits utilizing micro data is rare because of data availability, Koga (2003) estimates the elasticity of R&D tax credits on Japanese manufacturers from 1989 to 1998 and examines whether it varies with firm size. He finds that tax credits primarily stimulate R&D in large firms rather than medium-size firms. Baghana and Mohnen (2009) examine tax price elasticity for Canadian manufacturers from 1997 to 2003. In contrast to Koga (2003), they find that estimated elasticity for small firms is significantly negative, and for large firms it is insignificant.

Many studies, however, neglect the problem of selection bias. Recipients of tax credits might systematically differ from non-recipients in several characteristics. For instance, recipients might aspire to technological innovation and be more inclined than non-recipients to consolidate R&D systems. For this reason, estimating the mere difference in R&D between recipients and non-recipients is possibly a biased estimate. Correcting possible selection bias in the empirical analysis is important for assessing the effect of R&D tax credits.

Instead of evaluating the effects of tax credits on R&D expenditure, Czarnitzki et al. (2005) estimate their effects on innovation among Canadian manufacturers from 1997 to 1999. To correct selection bias, they use propensity score matching (PSM).[1] They find that tax credits encourage firms to conduct

[1] Several studies estimate the effects of R&D subsides using PSM. Duguet (2005),

R&D and to create and sell new and improved products. Huang and Yang (2009) investigate the effect of tax incentives on R&D among Taiwanese manufacturers. As a result of estimation employing PSM, they show that recipients of R&D tax credits appear on an average to spend 93.53% more on R&D and have a 14.47% higher growth rate for R&D expenditures compared to non-recipients with similar characteristics.[2] Onishi and Nagata (2009) apply difference-in-differences-PSM (DID-PSM) to estimate the impact of R&D tax credits on Japanese firms capitalized at ¥1 billion or more. They find no evidence that R&D tax credits influence R&D expenditure.[3]

R&D of small and medium-sized enterprises (SMEs) has another important aspect for the macroeconomy. Many empirical studies have found that Japan's total factor productivity (TFP) growth has slowed since the 1990s. Kim et al. (2010) summarize the structural causes of Japan's "Two Lost Decades" on the basis of broad-ranging empirical studies, and they argue that TFP of small firms has stagnated, while large firms have achieved greater increases in TFP since the mid-1990s. Since Kim et al. (2010) demonstrate that the gap in TFP growth is partly attributable to small firms' low R&D expenditures, enhancing R&D of small firms is key to Japan's economic growth.

We confirm these observations statistically. Figure 1 shows long-term changes in the ratio of R&D expenditures to sales of large enterprises and SMEs in manufacturing. Although the ratios for both large enterprises and SMEs have been increasing gradually, SMEs' expenditures have grown a mere 1.7 times since 1970 versus three-fold for large enterprises. Figure 2 shows the ratio of R&D expenditures to sales with respect to the number of employees in Japan and the United States. In the United States, the ratio of R&D has no relation to number of employees. In Japan, however, the smaller the workforce, the lower is the ratio of sales to R&D expenditures.

This paper uses firm-level micro data to estimate the effect of R&D tax credits on SMEs. We employ the matching method introduced by Rubin (1974), matching recipients of tax credits with non-recipients having the most similar characteristics. As we note, the matching method need not assume specific

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Heshmati and Lööf (2007), and Ito and Nakano (2009) find that R&D subsidies increase private R&D expenditures.

[2] Huang and Yang (2009) employ Generalized Method of Moment (GMM) for panel data to correct endogeneity bias. They find results similar to PSM analyses.

[3] However, their estimation does not satisfy the balancing property, which is important for verifying the validity of matching estimations, as we discuss later. In addition, their sample does not cover SMEs, which are the subject of this paper.

functional forms and can address systematic selection bias arising from application of R&D tax credits. Subdividing our samples by industry, firm size, and liquidity constraint, we also examine the efficiency of R&D tax credits by characteristics of firms.

Our empirical results show that offering R&D tax credits for Japanese SMEs more than doubled their R&D expenditures. Our findings indicate that R&D tax credits are effective policy instruments for inducing private R&D expenditure.

The paper is organized as follows. Section 2 introduces Japan's system of R&D tax credits for SMEs. Section 3 preliminarily examines our data and describes our empirical strategy. Section 4 presents estimation results and discussion. Section 5 concludes and proposes further subjects for future study.

2 Japanese System of R&D Tax Credits for SMEs

Japan introduced R&D tax credits in 1967. Initially, tax credits had been applied only to incremental R&D expenditures from the previous year, and no preferences were included for SMEs. Since then, R&D tax credits have been expanded and preferences for SMEs introduced.

Table 1 summarizes Japan's present system of R&D tax credits for SMEs. As the table shows, there are three types of credits: basic, incremental, and high-level.

SMEs can receive a credit equaling 12% of their total R&D expenditures, not exceeding an amount equal to 30% of their corporate taxes.

In addition, SMEs are eligible for an incremental credit if their R&D expenditures exceed "comparative R&D expenditures," i.e., average R&D expenditures for the past three years. The amount equals 5% of the difference between R&D expenditures and "comparative R&D expenditures," and not exceeding an amount equal to 10% of the company's corporate taxes.

The high-level credit permits companies to deduct an amount equal to 10% of the firm's corporate taxes if R&D expenditures surpasses "average sales" for the past three years. Companies may not claim the incremental and high-level credits simultaneously.

3 Empirical Strategy

3.1 Selection Bias

When assessing the effect of R&D tax credits, it is important to correct for possible selection bias in the empirical analysis. However, most studies that estimate elasticity of R&D tax credits regard them as an exogenous variable even though characteristics of recipients could differ from non-recipients. For example, a high level of R&D expenditure might not reflect the effect of tax credits but the characteristics of the firm. As a result, most research might be unable to identify the causal effects of the R&D credit.

Econometric evaluation techniques provide several estimation methods to correct for selection bias, including DID estimation, selection model, instrumental variables estimation (IV), and the matching method. Because our dataset is cross-sectional, we cannot utilize DID estimation because it requires panel data. Section model and IV estimation need instrumental variables that correlate treatment variables and not output variables. For these reasons, we apply the matching method introduced by Rubin (1997) and developed by Rosenbaum and Rubin (1983) and Heckman et al. (1997, 1998). Besides addressing endogeneity, the matching method has the advantage of not needing to assume a specific functional form.

3.2 Matching Method

The matching method is summarized as follows.[4] Let a binary treatment indicator D_i equal 1 if firms receive R&D tax credits and 0 otherwise. The potential outcomes are defined as $Y_i(D_i)$ for each firm i. In this paper, Y_i is R&D expenditures. The treatment effect for firm i is expressed as

$$\tau_i = Y_i(1) - Y_i(0). \tag{1}$$

However, we cannot observe $Y_i(0)$, the counterfactual outcome. Hence, estimating the individual treatment effect τ_i is impossible and we must estimate the average treatment effect (ATE). ATE is the difference in the expected outcomes between recipients and non-recipients.

[4] This discussion mostly depends on Caliendo and Kopeinig (2008).

$$\tau_{ATE} = E[Y_i(1) - Y_i(0)]. \tag{2}$$

Nevertheless, ATE might lack relevance because it includes effects on firms for which the program was never intended. Therefore, we estimate the average treatment effect on the treated (ATT), the effect on those for which the program is actually intended. ATT is expressed as

$$\tau_{ATT} = E[Y_i(1)|D = 1\,] - E[Y_i(0)|D = 1]. \tag{3}$$

Because $E[Y_i(0)|D = 1]$ is the counterfactual mean, we cannot observe it. However, using the mean outcome of untreated firms $E[Y_i(0)|D = 0]$ instead, we can generate a selection bias.

$$\begin{aligned} E[Y_i(1)|D = 1\,] - E[Y_i(0)|D = 0] = \tau_{ATT} \\ + E[Y_i(0)|D = 1\,] - E[Y_i(0)|D = 0]. \end{aligned} \tag{4}$$

The last two terms of Equation (4) are the selection bias. τ_{ATT} is precisely estimated in so far as $E[Y_i(0)|D = 1\,] - E[Y_i(0)|D = 0] = 0$. This condition satisfies in experiments of random assignment, but not in non-experimental studies. Rubin (1977) introduced the conditional independence assumption (CIA) to cope with the selection problem. CIA assumes that recipients and potential outcomes are independent for firms with identical exogenous covariates X. Covariates X consist of the set of characteristics that potentially effect receiving the R&D tax credit. If CIA is satisfied, we have the following equality.

$$E[Y_i(0)|D = 1, X] = E[Y_i(0)|D = 0, X] \tag{5}$$

This equality implies that the counterfactual outcome can be substituted for the outcomes of non-recipients, provided there are no systematic differences between the recipients group and the non-recipients group. Therefore, Equation (3) can be rewritten as

$$\tau_{ATT} = E[Y_i(1)|D = 1\,,\ X = x] - E[Y_i(0)|D = 0, X = x]. \tag{6}$$

To estimate the difference between outcomes of recipients and non-recipients,

we use the matching method introduced by Rubin (1974). Traditional matching estimators pair each recipient with an observable similar non-recipient and interpret the difference in outcomes as the effect of treatment. However, if we use many variables, it is difficult to match recipients and similar non-recipients. To construct a valid control group, Rosenbaum and Rubin (1983) suggest matching based on the propensity score ($P(D = 1|X = x)$), with the probability of receiving a treatment conditional on the covariates. In effect, we use probit estimation that regresses D_i on covariates X. Using the estimated propensity score of choosing to receive R&D tax credits, we can execute the matching algorithm to find the proper counterfactual. The matching procedure is successful if the means of covariates X among recipients and non-recipients do not differ significantly (balancing property).

3.3 Several Matching Approaches

We use kernel matching, k-nearest-neighbor matching, and caliper matching. Kernel matching is a nonparametric method that uses the weighted average of the non-recipients to construct the counterfactual outcome. We must choose the kernel function and the bandwidth in applying kernel matching. Econometricians acknowledge that the choice of kernel function is of slight importance, but choice of bandwidth is crucial because of the trade-off between bias and variance of estimates: high bandwidth induces large bias and small variance. We use Epanechnikov's kernel function and 0.05 as a bandwidth. K-nearest-neighbor matching matches k-closest firms in terms of propensity score. Choice of k also imposes a trade-off between bias and variance: large k leads to large bias and small variance. Based on earlier studies, we use 5 as k. Caliper matching can avoid bad matches by imposing a tolerance level on the maximum propensity score distance (caliper). In this paper, we use 0.05 as a tolerance level. While caliper matching has the advantage of small bias, variance of estimates increases when fewer matches are performed. Since there is no best matching approach, we use three alternative methods to compare estimation results.

3.4 Data and Variables

We utilize cross-sectional firm-level data from *The 2009 Basic Survey of Small and Medium Enterprises* conducted by the Small and Medium Enterprise Agency

of the Ministry of Economy, Trade, and Industry (METI). This survey collects information about SMEs [5] and covers industries such as construction, manufacturing, information and communications, wholesale and retail trade, and others. Our sampling is based on results of *The 2006 Establishment and Enterprise Census* from the Ministry of Internal Affairs and Communications. The valid response rate for this survey is 49.2% based on 55,636 completed questionnaires.

Table 2 shows descriptive statistics for recipients and non-recipients.[6] We realize that the average ln(R&D expenditure) among recipients is higher than among non-recipients. As discussed, however, this difference may result from selection bias, which we must correct when evaluating the effects of R&D tax credits.

Other variables in Table 2 are exogenous covariates X. To satisfy CIA, covariate X must consist of variables that potentially affect receiving the credits. We use the following variables as X: ln(total workers), percentage of indirect workers, percentage of women workers, recurring profit margin, dependence on debt ln(capital fund), a dummy for the foundation year, a dummy or financing by main banks, an industry dummy, and a region dummy.

The average ln(total workers) of recipients is also higher than among non-recipients, implying that recipients are relatively larger than non-recipients. Variables from $D_{1999\text{-}2000}$ to D_{2007} are dummies that show the year the firm was founded (base category is founded before 1999). Recipients of R&D tax credits are firms somewhat older than non-recipient firms. Variables ranging from the construction dummy to other service dummies show the firm's industry, and variables from the Hokkaido dummy to the Kyushu-Okinawa dummy indicate regions where a firm is located.

3.5 Sample Separation

Besides analyzing the whole sample, we subdivide the sample to examine the efficiency of R&D tax credits according to characteristics of firms.

First, we separate our sample by industry. In general, manufacturers are more

[5] For example, SMEs in manufacturing are companies capitalized at ¥300 million or less or employ 300 or fewer persons. For detailed definition of SMEs, consult the "Outline of the 2009 Basic Survey on Small and Medium Enterprises" on the web page of the Small and Medium Enterprise Agency.

[6] We do not analyze individual proprietorships because few apply for R&D tax credits.

R&D intensive than non-manufacturers. Descriptive statistics of our sample shown in Table 3 confirm that manufacturers are more R&D intensive and more likely to apply R&D tax credits than non-manufacturers. For this reason, examining the efficacy of R&D tax credits for manufacturers is highly significant for policy. Huang and Yang (2009) ascertain whether the effect of R&D tax credits varies among hi-tech and non-high-tech firms among Taiwanese manufacturers, and they reveal there is no significant difference.

Second, we focus on the effect of R&D tax credits by firm size. As mentioned, Koga (2003) finds that R&D tax credits have a greater effect on large firms than small firms, whereas the elasticity estimated by Baghana and Mohnen (2009) is significantly negative for small firms, unlike for large firms. By dividing firms into subgroups with 51 or more employees and 50 or fewer employees, we reexamine the effectiveness of R&D tax credits by firm size. Table 4 presents summary statistics by firm size.

Finally, we split firms according to whether they face liquidity constraints or not. Stiglitz and Weiss (1981) point out the importance of internal funding for uncertain investments such as R&D because of asymmetric information. This problem might be more serious for many small firms that cannot access financial markets directly. As a result, R&D tax credits might be effective for liquidity-constrained firms. *The 2009 Basic Survey of Small and Medium Enterprises* asks firms whether their main financial bank imposes conditions such as guarantees from business managers or third parties, requiring property as collateral, or insisting on public credit guarantees. If so, we define them as liquidity constrained. Descriptive statistics appear in Table 5.

4 Estimation Results

4.1 Probit Estimation

4.1.1 Whole sample

We first estimate the probit model to obtain the propensity score. Table 6 presents the estimation results. The following covariates are found to have significant influence on a firm's decision to apply for R&D tax credits.

The propensity to apply for R&D tax credits is positively associated with ln(total workers). This result indicates that larger firms tend to use R&D tax credits. Percentage of women workers has a negative effect on applying for

R&D tax credits.

Recurring profit margin has a positive influence on applying for the credit, and dependence on debt has a negative influence. These findings imply that firms applying for R&D tax credits are in good financial condition, because loss-making enterprises cannot claim them.

Firms established as a limited company (*yugen gaisha*) tend not to use R&D tax credits. Compared with *kabushiki gaisha* (base category), most *yugen gaisha* are small companies. For this reason, we expect the coefficient of the *yugen gaisha* dummy to be negative.

In contrast, dummies for the firm's year of founding, the main bank dummies, industry dummies, and regional dummies (excluding the Tohoku dummy) show no significant effects on applying for R&D tax credits. Covariates related to labor and finance are dominant in firms' decisions to apply for R&D tax credits.

4.1.2 Subsamples

Estimation results of the probit model using subsamples are shown in Table 7–9. Coefficients obtained using different subsamples are similar. However, differences between subsamples are as follows.

Among manufacturers, recurring profit margin has a positive influence on applying for R&D tax credits. For other variables, coefficients do not differ between manufacturers and non-manufacturers.

While a 1% increase in the total number of workers increases the probability of a large firm applying for the credit, it does not for small firms. In contrast, although the coefficient of dependence on debt is significantly negative for small firms, it is insignificant for large firms.

The coefficients of percentage of women workers and ln(capital fund) for firms lacking liquidity constraints are significantly negative. However, the propensity among firms with liquidity constraints is not significantly associated with these variables.

4.2 Effect of R&D Tax Credits

4.2.1 Whole sample

Table 10 shows the estimation results from matching estimators using propensity score retrieved from the probit model. The upper section of the table displays the result from kernel matching, the middle section describes the

k-nearest-neighbor matching estimates, and the lower section shows results from the k-nearest-neighbor matching. "Unmatched" shows the difference in ln(R&D expenditure) between recipients and non-recipients before matching, and "ATT" exhibits the average treatment effect on the treated, which is estimated using propensity score matching.

The first column of Table 4 displays average ln(R&D expenditure) of the treated group (recipients), and the second column presents that of the control group (non-recipients). The third column shows the difference between the first and second columns. The fourth column exhibits the standard error of the differences, and the fifth column is the t-value for the equivalence of difference in means between the treated and the control group.

In each matching method, all ATTs are smaller than the unmatched difference: the unmatched difference is 2.222, whereas ATTs are 1.183 (kernel), 1.241 (k-nearest-neighbor), and 1.433 (caliper). This implies that the unmatched difference, which neglects selection bias, is overestimated.

However, correcting selection bias using propensity score matching, estimated ATTs from all matching methods are still positive and statistically significant. Because the outcome variable is a natural logarithm of R&D expenditures, the estimated ATTs of 1.183–1.433 indicate that application of R&D tax credits increases R&D expenditure by more than double. These estimates resemble those of Huang and Yang (2009), which is 0.898–0.960. These imply that R&D tax credits are important for inducing R&D expenditures of SMEs in Japan.

4.2.2 Subsamples

Turning to the estimates for subsamples, Table 11 displays treatment effects by industry. Estimated ATT for non-manufacturers is larger than for manufacturers. Although manufacturers are more R&D intensive and tend to claim R&D tax credits, this finding implies that R&D tax credits are more effective for non-manufacturers.

Estimated results by firm size are shown in Table 12. There is little difference in ATT between large and small firms.

Estimates of ATT for firms with liquidity constraints are much larger than for firms without them. Internal funding is important for making investments in activities with uncertain outcomes, such as R&D. If liquidity-constrained firms have any difficulty raising capital externally, tax credits might be especially important. This prediction is supported by our estimation results above.

4.3 Tests of Balancing Property

As discussed in Subsection 3.2, we must confirm that the means of covariates between the recipient and the non-recipient groups do not differ significantly from zero. If they do not, our matching results can be regarded as reliable.

Table 14 shows the average covariates of each group and the standard t-test for the equity of mean sample values along with its p-value before and after matching. Before matching, the means of many covariates among recipients differ statistically from non-recipients. This finding indicates that the treated and control groups generally do not exhibit similar characteristics prior to matching. After matching, however, we cannot reject the null hypothesis of the t-test that the mean differences between recipients and non-recipients are equal for all covariates in every matching method.

Table 15 lists the joint significance tests and pseudo-R^2. In Table 15, "|%bias|" stands for the absolute percentage of mean difference between recipients and non-recipients. Means of |%bias| decrease considerably after matching. "Pseudo R^2" approaches zero if matching is successful. As the table shows, the pseudo R^2 and p-value of the LR-test approach zero.

In short, these statistical tests strongly support the legitimacy of our propensity matching estimates.[7]

5 Conclusion

Dormant R&D by SMEs contributed to the slowdown in Japan's TFP growth and its "Two Lost Decades."" Thus, it is especially important to induce an increase in R&D expenditure of SMEs. In many countries, R&D tax credits are a major policy tool to stimulate R&D. This paper analyses the effect of R&D tax credits on Japanese SMEs. We estimate ATT of R&D tax credits by propensity score matching to correct for selection bias. Our empirical results reveal that R&D tax credits positively influence SMEs' decisions to conduct R&D, and application of R&D tax credits more than doubles the R&D expenditure on an average. Therefore, tax credits are an effective instrument to foster R&D among SMEs. Moreover, estimating ATT using several subsamples, we found that ATT

[7] Balancing properties of subsamples are also satisfied. We have abbreviated their statistical tests because of space constraints.

for firms with liquidity constraints is much larger than for firms not facing liquidity constraints. This result might imply that R&D tax credits for liquidity-constrained firms are a more efficient policy because tax credits reinforce internal funds.

Our analyses have several limitations. First, even if R&D tax credits are effective policy instruments, they have limited use if few firms apply them. In effect, SMEs' ratio of application of R&D tax credits is a mere 0.26%.[8] And SMEs' R&D rate is 2.35%. It is necessary to study further the reasons behind this situation.

Second, Onishi and Nagata (2009) use propensity score matching in a way similar to our estimates and conclude that Japan's R&D tax credits do not induce R&D expenditures. There are several differences between this paper and theirs. For example, they utilize DID-PSM, whereas we use ordinary PSM. Heckman et al. (1997) show that DID-PSM often performs the best among the class of estimators they examine, especially when omitted time-invariant characteristics are important sources of bias. Regarding this point, estimates by Onishi and Nagata (2009) are more robust than ours. However, their matching does not satisfy the balancing property, and their matching results can not be deemed reliable. In addition, while our analyses focus on SMEs, Onishi and Nagata (2009) analyze large firms capitalized at ¥1 billion or more. Mindful of these differences, research into the effect of R&D tax credits must be advanced.

Third, we cannot determine the optimal level of R&D tax credits from our empirical results because our PSM analyses do not identify their general equilibrium effects. Further scholarship would benefit from general equilibrium analyses to determine socially optimum tax credits.

Finally, if we utilize panel data, we obtain robust and detailed estimates. Using panel data, we can take advantage of DID-PSM as noted above. Furthermore, while we have no choice but to employ covariates of same-year R&D expenditures, using lags of covariates is preferable.

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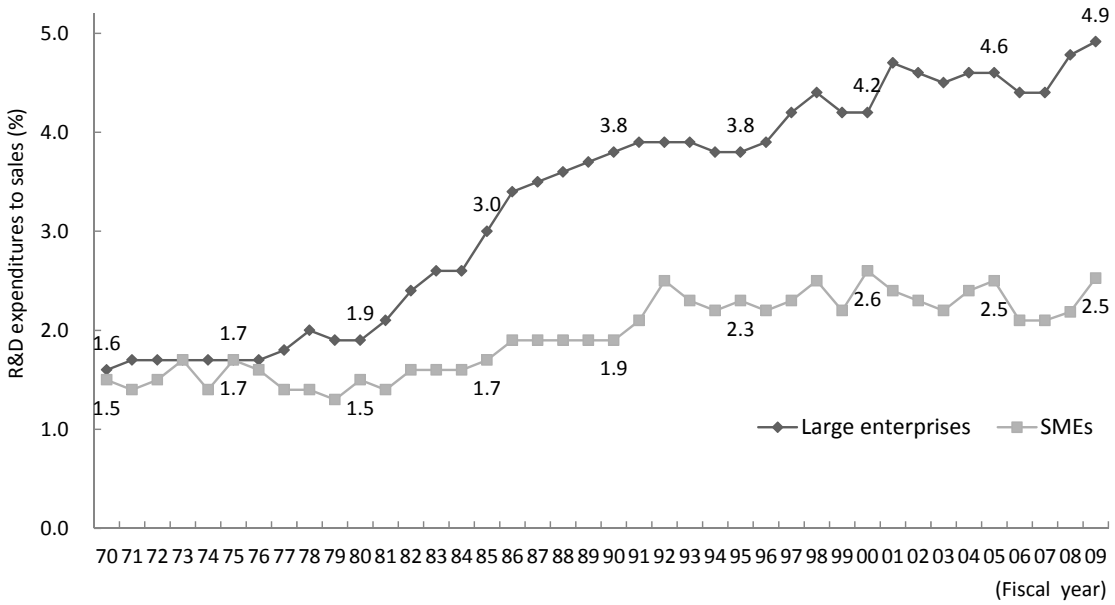
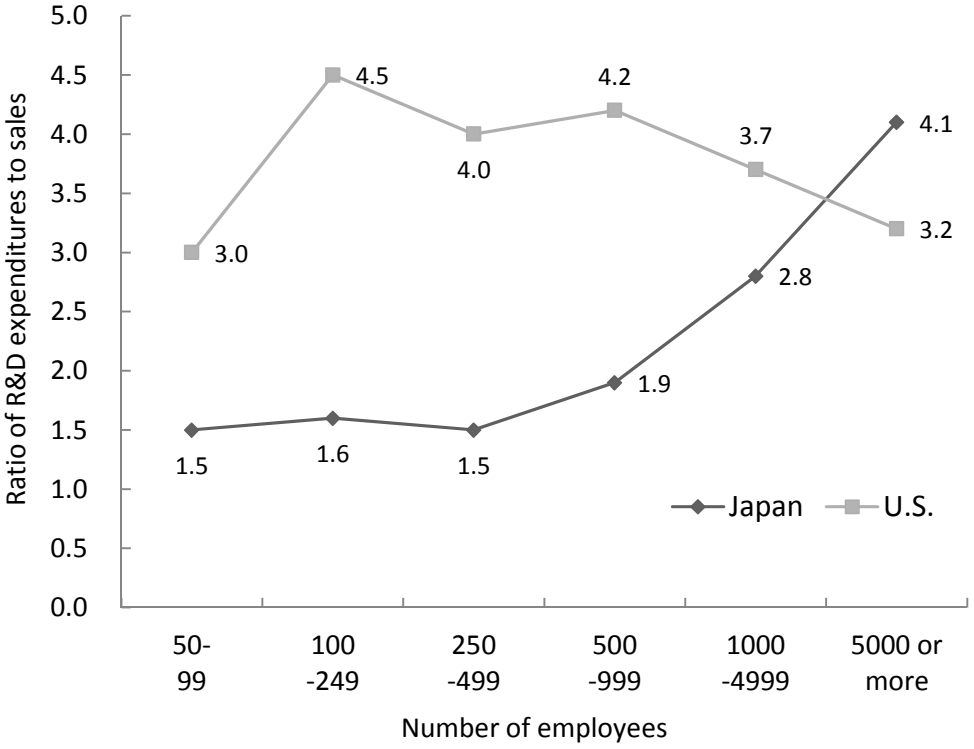
Figure 1 Changes in R&D expenditures of SMEs and large enterprises (manufacturing)



Source: Ministry of Internal Affairs and Communications, *Survey of Research and Development*

Notes: Enterprises with workforces of 1 to 299 employees are considered SMEs, and those employing 300 or more are considered large enterprises. R&D expenditures include both internal and external expenditures. Data are for enterprises engaging in R&D.

Figure 2 Ratio of R&D expenditures to sales by number of employees in Japan and the U.S. (manufacturing)



Source: Small and Medium Enterprise Agency of Japan, *2009 White Paper on Small and Medium Enterprise in Japan*

Notes: Data for enterprises that responded about R&D in Japan and the U.S. federal subsidies are not included for the U.S. To match the value definition of the U.S., R&D expenditures for outsourced work were excluded from R&D expenditures, and R&D expenditures for commissioned work were included in Japanese values.

Table 1 Summary of Japanese system of R&D tax credits for SMEs

Types	Basic type	Incremental type	High-level type
Subject of tax credits	Total amount of R&D expenditure	R&D expenditure above "comparative R&D expenditure"	R&D expenditure above 10% of "average sales"
Tax credit rate	12%	5%	(R&D/Sales-10%)×0.2
Upper limit of tax credits	30% of the company's corporation tax	10% of the company's corporation tax	10% of the company's corporation tax

Source: Small and Medium Enterprise Agency of Japan

Notes: As of 2009. "Comparative R&D expenditure" is defined as average R&D expenditure for the past three years. "Average sales" is defined as average sales for the past three years.

Table 2 Descriptive statistics: all firms

	All firms		recipients		non-recipients	
	mean	sd	mean	sd	mean	sd
ln(R&D expenditure)	7.9	2.2	9.8	1.7	7.6	2.1
ln(total workers)	3.5	1.4	4.3	1.1	3.3	1.4
Percentage of indirect workers	3.4	10.0	5.4	11.5	3.1	9.8
Percentage of women workers	36.0	22.0	29.1	17.0	37.1	22.5
Recurring profit margin	-1.1	36.4	4.5	8.1	-1.9	38.8
Dependence on debt	63.6	403.5	29.0	23.8	68.7	432.0
ln(capital fund)	10.0	1.2	10.5	1.1	9.9	1.2
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	0.048	0.213	0.011	0.103	0.053	0.224
D_{2002}=1{founded at 2002}	0.017	0.130	0.005	0.073	0.019	0.136
D_{2003}=1{founded at 2003}	0.010	0.101	0.005	0.073	0.011	0.105
D_{2004}=1{founded at 2004}	0.014	0.119	0.016	0.126	0.014	0.118
D_{2005}=1{founded at 2005}	0.010	0.098	0.005	0.073	0.010	0.101
D_{2006}=1{founded at 2006}	0.008	0.087	0.005	0.073	0.008	0.089
D_{2007}=1{founded at 2007}	0.001	0.037	0.005	0.073	0.001	0.028
D_{city}=1{main financing bank is the city bank}	0.398	0.490	0.545	0.499	0.376	0.485
D_{local}=1{main financing bank is the local bank}	0.370	0.483	0.364	0.482	0.371	0.483
D_{union}=1{main financing bank is the credit union}	0.165	0.371	0.048	0.215	0.182	0.386
D_{yugen}=1{set up as a limited company}	0.151	0.358	0.011	0.103	0.172	0.377
Construction dummy	0.024	0.153	0.021	0.145	0.025	0.155
Manufacturing dummy	0.587	0.492	0.813	0.391	0.554	0.497
Information and communications dummy	0.069	0.253	0.011	0.103	0.077	0.267
Transport and postal activities dummy	0.008	0.087	0.005	0.073	0.008	0.089
Wholesale dummy	0.090	0.287	0.064	0.246	0.094	0.292
Real estate and goods rental and leasing dummy	0.017	0.128	0.011	0.103	0.017	0.131
Private service dummy	0.046	0.210	0.037	0.190	0.047	0.213
Accommodations, eating and drinking service dummy	0.048	0.213	0.005	0.073	0.054	0.226
Living-related and personal services and amusement services dummy	0.050	0.219	0.005	0.073	0.057	0.232
Other service dummy	0.014	0.117	0.021	0.145	0.013	0.112
Hokkaid dummy	0.024	0.153	0.005	0.073	0.027	0.162
Tohoku dummy	0.055	0.228	0.016	0.126	0.061	0.239
Chubu dymmy	0.111	0.314	0.102	0.303	0.112	0.316
Kinki dummy	0.201	0.401	0.267	0.444	0.191	0.393
Chugoku dummy	0.048	0.214	0.070	0.255	0.045	0.208
Shikoku dummy	0.023	0.151	0.011	0.103	0.025	0.157
Kyushu-Okinawa dummy	0.058	0.234	0.059	0.236	0.058	0.233
sample size	1452		187		1265	

Table 3 Descriptive statistics: by industry

	Manufacturing				Non-manufacturing			
	recipients		non-recipients		recipients		non-recipients	
	mean	sd	mean	sd	mean	sd	mean	sd
ln(R&D expenditure)	10.0	1.7	8.1	2.0	8.8	1.7	7.1	2.1
ln(total workers)	4.4	1.0	3.8	1.1	4.0	1.4	3.0	1.5
Percentage of indirect workers	4.7	10.4	3.4	8.5	8.2	15.5	2.8	11.2
Percentage of women workers	29.1	15.8	31.9	19.0	29.1	22.0	42.1	24.4
Recurring profit margin	4.4	7.6	-0.9	24.3	4.7	10.4	0.0	14.6
Dependence on debt	30.0	23.4	48.2	49.2	23.7	24.7	87.4	653.3
ln(capital fund)	10.6	1.1	10.3	1.0	10.0	0.8	9.6	1.2
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	0.007	0.081	0.030	0.169	0.029	0.169	0.081	0.272
D_{2002}=1{founded at 2002}	0.000	0.000	0.000	0.000	0.029	0.169	0.029	0.169
D_{2003}=1{founded at 2003}	0.007	0.081	0.005	0.070	0.000	0.000	0.000	0.000
D_{2004}=1{founded at 2004}	0.007	0.081	0.005	0.070	0.057	0.236	0.022	0.147
D_{2005}=1{founded at 2005}	0.000	0.000	0.000	0.000	0.029	0.169	0.013	0.113
D_{2006}=1{founded at 2006}	0.007	0.081	0.003	0.057	0.000	0.000	0.000	0.000
D_{2007}=1{founded at 2007}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D_{city}=1{main financing bank is the city bank}	0.556	0.498	0.407	0.492	0.514	0.507	0.372	0.484
D_{local}=1{main financing bank is the local bank}	0.371	0.485	0.361	0.481	0.314	0.471	0.361	0.481
D_{union}=1{main financing bank is the credit union}	0.026	0.161	0.159	0.366	0.143	0.355	0.192	0.394
D_{yugen}=1{set up as a limited company}	0.000	0.000	0.000	0.000	0.057	0.236	0.256	0.437
Construction dummy	0.000	0.000	0.000	0.000	0.114	0.323	0.057	0.232
Manufacturing dummy	1.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
Information and communications dummy	0.000	0.000	0.000	0.000	0.057	0.236	0.168	0.375
Transport and postal activities dummy	0.000	0.000	0.000	0.000	0.029	0.169	0.018	0.134
Wholesale dummy	0.000	0.000	0.000	0.000	0.343	0.482	0.212	0.409
Real estate and goods rental and leasing dummy	0.000	0.000	0.000	0.000	0.057	0.236	0.040	0.197
Private service dummy	0.000	0.000	0.000	0.000	0.200	0.406	0.108	0.311
Accommodations, eating and drinking service dummy	0.000	0.000	0.000	0.000	0.029	0.169	0.117	0.322
Living-related and personal services and amusement services dummy	0.000	0.000	0.000	0.000	0.029	0.169	0.130	0.337
Other service dummy	0.000	0.000	0.000	0.000	0.114	0.323	0.027	0.164
Hokkaid dummy	0.000	0.000	0.000	0.000	0.029	0.169	0.040	0.197
Tohoku dummy	0.013	0.115	0.054	0.227	0.029	0.169	0.060	0.239
Chubu dymmy	0.106	0.309	0.133	0.340	0.086	0.284	0.086	0.281
Kinki dummy	0.265	0.443	0.232	0.422	0.286	0.458	0.150	0.358
Chugoku dummy	0.066	0.250	0.039	0.195	0.086	0.284	0.051	0.221
Shikoku dummy	0.007	0.081	0.016	0.127	0.029	0.169	0.035	0.183
Kyushu-Okinawa dummy	0.046	0.211	0.038	0.191	0.114	0.323	0.075	0.264
sample size	151		609		35		546	

Table 4 Descriptive statistics: by firm size

	51 or more employees				50 or fewer employees			
	recipients		non-recipients		recipients		non-recipients	
	mean	sd	mean	sd	mean	sd	mean	sd
ln(R&D expenditure)	10.3	1.4	8.7	2.0	8.8	1.8	7.0	1.9
ln(total workers)	4.9	0.6	4.8	0.6	3.1	0.8	2.6	1.0
Percentage of indirect workers	5.3	11.1	4.0	7.8	5.5	12.5	2.5	9.9
Percentage of women workers	29.7	16.2	34.4	20.0	27.9	18.7	37.7	22.9
Recurring profit margin	4.3	7.0	1.4	7.8	4.6	10.0	-2.4	30.6
Dependence on debt	30.2	22.7	40.1	28.5	26.4	25.4	86.6	596.5
ln(capital fund)	10.8	1.1	10.8	1.0	10.0	0.9	9.5	1.0
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	0.000	0.000	0.000	0.000	0.030	0.173	0.049	0.215
D_{2002}=1{founded at 2002}	0.000	0.000	0.000	0.000	0.015	0.123	0.012	0.110
D_{2003}=1{founded at 2003}	0.000	0.000	0.000	0.000	0.015	0.123	0.009	0.095
D_{2004}=1{founded at 2004}	0.025	0.157	0.008	0.088	0.000	0.000	0.000	0.000
D_{2005}=1{founded at 2005}	0.000	0.000	0.000	0.000	0.015	0.123	0.012	0.110
D_{2006}=1{founded at 2006}	0.000	0.000	0.000	0.000	0.015	0.123	0.009	0.095
D_{2007}=1{founded at 2007}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D_{city}=1{main financing bank is the city bank}	0.575	0.496	0.464	0.499	0.500	0.504	0.346	0.476
D_{local}=1{main financing bank is the local bank}	0.367	0.484	0.391	0.489	0.348	0.480	0.341	0.475
D_{union}=1{main financing bank is the credit union}	0.025	0.157	0.081	0.273	0.091	0.290	0.246	0.431
D_{yugen}=1{set up as a limited company}	0.000	0.000	0.000	0.000	0.030	0.173	0.228	0.420
Construction dummy	0.017	0.129	0.031	0.174	0.030	0.173	0.018	0.134
Manufacturing dummy	0.867	0.341	0.698	0.460	0.712	0.456	0.592	0.492
Information and communications dummy	0.017	0.129	0.042	0.200	0.000	0.000	0.000	0.000
Transport and postal activities dummy	0.008	0.091	0.003	0.051	0.000	0.000	0.012	0.110
Wholesale dummy	0.033	0.180	0.068	0.252	0.121	0.329	0.121	0.327
Real estate and goods rental and leasing dummy	0.008	0.091	0.003	0.051	0.015	0.123	0.030	0.172
Private service dummy	0.033	0.180	0.047	0.212	0.045	0.210	0.053	0.224
Accommodations, eating and drinking service dummy	0.008	0.091	0.078	0.269	0.000	0.000	0.000	0.000
Living-related and personal services and amusement services dummy	0.000	0.000	0.000	0.000	0.015	0.123	0.077	0.267
Other service dummy	0.008	0.091	0.003	0.051	0.045	0.210	0.021	0.144
Hokkaid dummy	0.008	0.091	0.036	0.188	0.000	0.000	0.000	0.000
Tohoku dummy	0.025	0.157	0.055	0.228	0.000	0.000	0.000	0.000
Chubu dymmy	0.142	0.350	0.128	0.334	0.030	0.173	0.124	0.330
Kinki dummy	0.308	0.464	0.214	0.410	0.197	0.401	0.208	0.406
Chugoku dummy	0.042	0.201	0.055	0.228	0.121	0.329	0.041	0.198
Shikoku dummy	0.008	0.091	0.018	0.134	0.015	0.123	0.027	0.163
Kyushu-Okinawa dummy	0.050	0.219	0.044	0.206	0.076	0.267	0.061	0.239
sample size	120		384		66		659	

Table 5 Descriptive statistics: by liquidity constraint

	Liquidity constraint				Non-liquidity constraint			
	recipients		non-recipients		recipients		non-recipients	
	mean	sd	mean	sd	mean	sd	mean	sd
ln(R&D expenditure)	9.9	1.6	7.7	2.0	9.6	2.0	7.9	2.4
ln(total workers)	4.3	1.0	3.3	1.3	4.3	1.3	3.3	1.6
Percentage of indirect workers	4.1	9.2	2.5	8.2	8.5	15.6	5.2	12.8
Percentage of women workers	28.9	16.4	34.3	20.5	29.5	18.7	37.9	23.7
Recurring profit margin	3.8	7.6	-1.4	26.5	6.2	9.2	-0.4	18.6
Dependence on debt	35.3	22.3	76.6	528.2	13.1	19.8	44.1	104.8
ln(capital fund)	10.5	1.1	9.9	1.1	10.5	1.1	10.1	1.3
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	0.007	0.086	0.048	0.214	0.019	0.137	0.071	0.257
D_{2002}=1{founded at 2002}	0.007	0.086	0.017	0.129	0.000	0.000	0.000	0.000
D_{2003}=1{founded at 2003}	0.000	0.000	0.000	0.000	0.019	0.137	0.015	0.121
D_{2004}=1{founded at 2004}	0.007	0.086	0.010	0.098	0.038	0.192	0.022	0.148
D_{2005}=1{founded at 2005}	0.007	0.086	0.010	0.098	0.000	0.000	0.000	0.000
D_{2006}=1{founded at 2006}	0.007	0.086	0.006	0.077	0.000	0.000	0.000	0.000
D_{2007}=1{founded at 2007}	0.000	0.000	0.000	0.000	0.019	0.137	0.004	0.061
D_{city}=1{main financing bank is the city bank}	0.478	0.501	0.342	0.475	0.717	0.455	0.597	0.491
D_{local}=1{main financing bank is the local bank}	0.396	0.491	0.386	0.487	0.283	0.455	0.276	0.448
D_{union}=1{main financing bank is the credit union}	0.067	0.251	0.185	0.388	0.000	0.000	0.116	0.320
D_{yugen}=1{set up as a limited company}	0.007	0.086	0.135	0.342	0.019	0.137	0.153	0.361
Construction dummy	0.022	0.148	0.025	0.157	0.019	0.137	0.026	0.160
Manufacturing dummy	0.828	0.378	0.639	0.481	0.774	0.423	0.556	0.498
Information and communications dummy	0.007	0.086	0.084	0.277	0.019	0.137	0.086	0.281
Transport and postal activities dummy	0.007	0.086	0.008	0.091	0.000	0.000	0.000	0.000
Wholesale dummy	0.067	0.251	0.106	0.307	0.057	0.233	0.097	0.297
Real estate and goods rental and leasing dummy	0.007	0.086	0.024	0.153	0.019	0.137	0.007	0.086
Private service dummy	0.037	0.190	0.043	0.203	0.038	0.192	0.063	0.244
Accommodations, eating and drinking service dummy	0.000	0.000	0.000	0.000	0.019	0.137	0.030	0.170
Living-related and personal services and amusement services dummy	0.000	0.000	0.000	0.000	0.019	0.137	0.063	0.244
Other service dummy	0.022	0.148	0.017	0.129	0.019	0.137	0.004	0.061
Hokkaid dummy	0.000	0.000	0.000	0.000	0.019	0.137	0.015	0.121
Tohoku dummy	0.007	0.086	0.054	0.226	0.038	0.192	0.071	0.257
Chubu dymmy	0.112	0.316	0.120	0.325	0.075	0.267	0.119	0.325
Kinki dummy	0.254	0.437	0.180	0.384	0.302	0.463	0.269	0.444
Chugoku dummy	0.067	0.251	0.042	0.201	0.075	0.267	0.052	0.223
Shikoku dummy	0.015	0.122	0.029	0.167	0.000	0.000	0.000	0.000
Kyushu-Okinawa dummy	0.052	0.223	0.052	0.221	0.075	0.267	0.052	0.223
sample size	134		834		53		268	

Table 6 Determinants of R&D tax credits using probit model: all firms

	Coef	SE	z	p-value
ln(total workers)	0.259 ***	0.053	4.87	0.000
Percentage of indirect workers	0.003	0.004	0.63	0.527
Percentage of women workers	-0.005 ***	0.003	-1.78	0.075
Recurring profit margin	0.017 ***	0.005	3.05	0.002
Dependence on debt	-0.008 ***	0.002	-4.23	0.000
ln(capital fund)	-0.054	0.056	-0.96	0.335
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	-0.115	0.358	-0.32	0.749
D_{2002}=1{founded at 2002}	-0.121	0.514	-0.24	0.813
D_{2003}=1{founded at 2003}	0.384	0.571	0.67	0.502
D_{2004}=1{founded at 2004}	0.632	0.459	1.38	0.169
D_{2005}=1{founded at 2005}	0.137	0.550	0.25	0.803
D_{2006}=1{founded at 2006}	0.045	0.680	0.07	0.947
D_{2007}=1{founded at 2007}	1.631	1.043	1.56	0.118
D_{city}=1{main financing bank is the city bank}	0.312	0.218	1.43	0.152
D_{local}=1{main financing bank is the local bank}	0.238	0.221	1.08	0.282
D_{union}=1{main financing bank is the credit union}	-0.008	0.271	-0.03	0.976
D_{yugen}=1{set up as a limited company(yugen gaisha)}	-0.689 ***	0.356	-1.93	0.053
Construction dummy	0.263	0.557	0.47	0.638
Manufacturing dummy	0.609	0.456	1.34	0.182
Information and communications dummy	-0.558	0.555	-1.00	0.315
Transport and postal activities dummy	0.687	0.745	0.92	0.357
Wholesale dummy	0.274	0.482	0.57	0.570
Real estate and goods rental and leasing dummy	0.311	0.616	0.50	0.614
Private service dummy	0.339	0.508	0.67	0.505
Accommodations, eating and drinking service dummy	-0.985	0.720	-1.37	0.171
Living-related and personal services and amusement services dummy	-0.082	0.634	-0.13	0.898
Other service dummy	0.819	0.589	1.39	0.164
Hokkaid dummy	-0.587	0.516	-1.14	0.255
Tohoku dummy	-0.646 **	0.313	-2.06	0.039
Chubu dymmy	-0.187	0.162	-1.15	0.249
Kinki dummy	0.078	0.120	0.65	0.515
Chugoku dummy	0.337	0.217	1.55	0.121
Shikoku dummy	-0.030	0.394	-0.08	0.940
Kyushu-Okinawa dummy	0.218	0.229	0.95	0.341
Constant	-1.792 **	0.734	-2.44	0.015
Log likelihood	-442.917			
Pseudo R-squared	0.206			
sample size	1452			

Note: Asterisks ***, **, and * indicate statistical significance at the .01, .05, and .10 levels, respectively.

Table 7 Determinants of R&D tax credits using probit model: by industry

	Manufacturing				Non-manufacturing			
	Coef	SE	z	p-value	Coef	SE	z	p-value
ln(total workers)	0.269 ***	0.068	3.95	0.000	0.279 ***	0.093	2.99	0.003
Percentage of indirect workers	-0.001	0.006	-0.13	0.895	0.009	0.007	1.31	0.191
Percentage of women workers	-0.003	0.003	-0.91	0.364	-0.008	0.006	-1.42	0.154
Recurring profit margin	0.022 ***	0.007	3.13	0.002	0.012	0.010	1.13	0.259
Dependence on debt	-0.006 ***	0.002	-2.75	0.006	-0.012 ***	0.004	-2.95	0.003
ln(capital fund)	-0.016	0.065	-0.25	0.803	-0.179	0.134	-1.34	0.181
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	-0.299	0.521	-0.57	0.566	0.067	0.572	0.12	0.907
D_{2002}=1{founded at 2002}					0.441	0.582	0.76	0.448
D_{2003}=1{founded at 2003}	0.897	0.718	1.25	0.212				
D_{2004}=1{founded at 2004}	0.047	0.776	0.06	0.951	1.215 **	0.580	2.09	0.036
D_{2005}=1{founded at 2005}					0.652	0.659	0.99	0.323
D_{2006}=1{founded at 2006}	1.008	1.014	0.99	0.320				
D_{city}=1{main financing bank is the city bank}	0.257	0.245	1.05	0.295	0.544	0.596	0.91	0.362
D_{local}=1{main financing bank is the local bank}	0.218	0.248	0.88	0.379	0.407	0.610	0.67	0.504
D_{union}=1{main financing bank is the credit union}	-0.457	0.339	-1.35	0.177	0.958	0.651	1.47	0.141
D_{yugen}=1{set up as a limited company(yugen gaisha)}					-0.759	0.524	-1.45	0.148
Construction dummy					0.192	0.667	0.29	0.773
Information and communications dummy					-0.507	0.656	-0.77	0.440
Transport and postal activities dummy					0.800	0.837	0.95	0.340
Wholesale dummy					0.314	0.566	0.56	0.578
Real estate and goods rental and leasing dummy					0.365	0.697	0.52	0.601
Private service dummy					0.296	0.604	0.49	0.624
Accommodations, eating and drinking service dummy					-1.272	0.882	-1.44	0.149
Living-related and personal services and amusement services dummy					-0.113	0.669	-0.17	0.866
Other service dummy					0.894	0.690	1.30	0.195
Hokkaid dummy					-0.004	0.622	-0.01	0.995
Tohoku dummy	-0.897 **	0.393	-2.28	0.022	-0.091	0.574	-0.16	0.874
Chubu dymmy	-0.290	0.187	-1.56	0.120	0.181	0.371	0.49	0.626
Kinki dummy	-0.031	0.139	-0.22	0.825	0.401	0.272	1.47	0.140
Chugoku dummy	0.204	0.259	0.79	0.431	0.712	0.435	1.64	0.102
Shikoku dummy	-0.541	0.556	-0.97	0.331	0.721	0.627	1.15	0.250
Kyushu-Okinawa dummy	-0.028	0.285	-0.10	0.921	0.870 **	0.433	2.01	0.044
Constant	-1.600 **	0.676	-2.37	0.018	-0.966	1.522	-0.63	0.526
Log likelihood	-330.142				-94.996			
Pseudo R-squared	0.129				0.282			
sample size	760				581			

Note: Asterisks ***, **, and * indicate statistical significance at the .01, .05, and .10 levels, respectively.

Table 8 Determinants of R&D tax credits using probit model: by firm size

	51 or more employees				50 or fewer employees			
	Coef	SE	z	p-value	Coef	SE	z	p-value
ln(total workers)	0.241 ***	0.133	1.81	0.071	0.169	0.105	1.61	0.108
Percentage of indirect workers	0.005	0.007	0.68	0.498	-0.001	0.007	-0.10	0.919
Percentage of women workers	-0.005	0.004	-1.16	0.246	-0.004	0.004	-1.00	0.318
Recurring profit margin	0.022 **	0.009	2.49	0.013	0.015 **	0.007	2.07	0.039
Dependence on debt	-0.004	0.003	-1.43	0.154	-0.011 ***	0.003	-4.02	0.000
ln(capital fund)	-0.099	0.073	-1.36	0.175	0.058	0.101	0.58	0.562
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}					0.248	0.415	0.60	0.550
D_{2002}=1{founded at 2002}					0.520	0.636	0.82	0.414
D_{2003}=1{founded at 2003}					1.090	0.699	1.56	0.119
D_{2004}=1{founded at 2004}	1.210 ***	0.665	1.82	0.069				
D_{2005}=1{founded at 2005}					0.609	0.630	0.97	0.334
D_{2006}=1{founded at 2006}					0.261	0.730	0.36	0.720
D_{city}=1{main financing bank is the city bank}	0.367	0.315	1.16	0.244	0.124	0.319	0.39	0.698
D_{local}=1{main financing bank is the local bank}	0.351	0.319	1.10	0.272	-0.022	0.327	-0.07	0.947
D_{union}=1{main financing bank is the credit union}	-0.102	0.453	-0.22	0.823	-0.143	0.367	-0.39	0.696
D_{yugen}=1{set up as a limited company(yugen gaisha)}					-0.641	0.414	-1.55	0.121
Construction dummy	-0.107	0.721	-0.15	0.882	0.601	0.689	0.87	0.383
Manufacturing dummy	0.576	0.543	1.06	0.289	0.321	0.530	0.60	0.546
Information and communications dummy	-0.109	0.685	-0.16	0.874				
Wholesale dummy	-0.103	0.618	-0.17	0.868	0.275	0.560	0.49	0.623
Real estate and goods rental and leasing dummy	1.532	1.440	1.06	0.287	-0.169	0.738	-0.23	0.819
Private service dummy	0.175	0.648	0.27	0.787	0.208	0.606	0.34	0.731
Accommodations, eating and drinking service dummy	-1.251	0.910	-1.37	0.169				
Living-related and personal services and amusement services dummy					-0.224	0.714	-0.31	0.753
Other service dummy	0.645	1.119	0.58	0.564	0.546	0.676	0.81	0.419
Hokkaid dummy	-0.492	0.558	-0.88	0.378				
Tohoku dummy	-0.443	0.367	-1.21	0.227				
Chubu dymmy	0.023	0.207	0.11	0.912	-0.680 **	0.342	-1.99	0.046
Kinki dummy	0.226	0.163	1.38	0.167	-0.137	0.196	-0.70	0.484
Chugoku dummy	-0.015	0.339	-0.05	0.964	0.679 **	0.299	2.27	0.023
Shikoku dummy	0.013	0.597	0.02	0.982	-0.101	0.593	-0.17	0.864
Kyushu-Okinawa dummy	0.156	0.324	0.48	0.630	0.334	0.345	0.97	0.332
Constant	-1.408	1.106	-1.27	0.203	-2.110 ***	1.119	-1.89	0.059
Log likelihood	-245.493				-177.553			
Pseudo R-squared	0.113				0.197			
sample size	504				725			

Note: Asterisks ***, **, and * indicate statistical significance at the .01, .05, and .10 levels, respectively.

Table 9 Determinants of R&D tax credits using probit model: by liquidity constraints

	Liquidity constraint				Non-liquidity constraint			
	Coef	SE	z	p-value	Coef	SE	z	p-value
ln(total workers)	0.270 ***	0.065	4.18	0.000	0.310 ***	0.101	3.08	0.002
Percentage of indirect workers	0.002	0.006	0.34	0.737	0.010	0.008	1.39	0.166
Percentage of women workers	-0.005	0.003	-1.36	0.174	-0.012 **	0.006	-2.02	0.043
Recurring profit margin	0.014 ***	0.007	1.89	0.059	0.022 **	0.009	2.41	0.016
Dependence on debt	-0.011 ***	0.002	-4.34	0.000	-0.007 ***	0.004	-1.76	0.079
ln(capital fund)	0.027	0.065	0.41	0.680	-0.255 **	0.120	-2.13	0.033
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	-0.314	0.494	-0.63	0.526	-0.018	0.660	-0.03	0.979
D_{2002}=1{founded at 2002}	0.097	0.567	0.17	0.865				
D_{2003}=1{founded at 2003}					1.303	0.864	1.51	0.132
D_{2004}=1{founded at 2004}	0.899	0.786	1.14	0.253	0.497	0.669	0.74	0.457
D_{2005}=1{founded at 2005}	0.632	0.663	0.95	0.341				
D_{2006}=1{founded at 2006}	0.255	0.724	0.35	0.725				
D_{2007}=1{founded at 2007}					1.707	1.187	1.44	0.150
D_{local}=1{main financing bank is the local bank}	0.002	0.124	0.02	0.987	-0.091	0.260	-0.35	0.727
D_{yugen}=1{set up as a limited company(yugen gaisha)}	-0.874 ***	0.529	-1.65	0.099	-0.817	0.648	-1.26	0.207
Construction dummy	0.481	0.622	0.77	0.439	-0.951	0.986	-0.96	0.335
Manufacturing dummy	0.739	0.493	1.50	0.134	-0.085	0.692	-0.12	0.903
Information and communications dummy	-0.423	0.663	-0.64	0.523	-1.490	0.924	-1.61	0.107
Wholesale dummy	0.452	0.529	0.85	0.393	-0.611	0.765	-0.80	0.424
Real estate and goods rental and leasing dummy	0.220	0.732	0.30	0.764	0.143	1.187	0.12	0.904
Private service dummy	0.526	0.565	0.93	0.352	-0.924	0.861	-1.07	0.283
Accommodations, eating and drinking service dummy					-0.866	1.020	-0.85	0.396
Living-related and personal services and amusement services dummy					-0.368	0.835	-0.44	0.660
Other service dummy	0.921	0.659	1.40	0.162	0.690	1.384	0.50	0.618
Hokkaid dummy					1.324	0.890	1.49	0.137
Tohoku dummy	-0.963 **	0.481	-2.00	0.045	-0.057	0.498	-0.12	0.908
Chubu dymmy	-0.145	0.187	-0.78	0.436	-0.334	0.350	-0.95	0.340
Kinki dummy	0.119	0.144	0.83	0.408	0.124	0.235	0.53	0.597
Chugoku dummy	0.421	0.261	1.61	0.106	0.281	0.443	0.63	0.526
Shikoku dummy	0.011	0.424	0.03	0.980				
Kyushu-Okinawa dummy	0.080	0.270	0.29	0.768	0.756	0.530	1.43	0.153
Constant	-2.434 ***	0.806	-3.02	0.003	1.081	1.285	0.84	0.400
Log likelihood	-315.979				-113.272			
Pseudo R-squared	0.188				0.212			
sample size	968				321			

Note: Asterisks ***, **, and * indicate statistical significance at the .01, .05, and .10 levels, respectively.

Table 10 Treatment effects of R&D tax credits on R&D expenditure: all firms

		Treated	Controls	Difference	SE	t-value
Kernel	Unmatched	9.803	7.581	2.222	0.162	13.74
	ATT	9.803	8.620	1.183	0.167	7.10
K-nearest-neighbor	Unmatched	9.803	7.581	2.222	0.162	13.74
	ATT	9.803	8.562	1.241	0.176	7.06
Caliper	Unmatched	9.803	7.581	2.222	0.162	13.74
	ATT	9.801	8.368	1.433	0.218	6.57

Table 11 Treatment effects of R&D tax credits on R&D expenditure: by industry

			Treated	Controls	Difference	SE	t-value
Manufacturing	Kernel	Unmatched	10.025	8.146	1.878	0.179	10.50
		ATT	10.035	8.761	1.275	0.175	7.28
	K-nearest-neighbor	Unmatched	10.025	8.146	1.878	0.179	10.50
		ATT	10.025	8.827	1.197	0.195	6.13
	Caliper	Unmatched	10.025	8.146	1.878	0.179	10.50
		ATT	10.035	8.957	1.078	0.233	4.62
Non-manufacturing	Kernel	Unmatched	8.838	7.067	1.772	0.354	5.00
		ATT	8.885	7.464	1.421	0.374	3.80
	K-nearest-neighbor	Unmatched	8.838	7.067	1.772	0.354	5.00
		ATT	8.871	7.207	1.664	0.386	4.31
	Caliper	Unmatched	8.838	7.067	1.772	0.354	5.00
		ATT	8.885	6.978	1.908	0.498	3.83

Table 12 Treatment effects of R&D tax credits on R&D expenditure: by firm size

			Treated	Controls	Difference	SE	t-value
51 or more employees	Kernel	Unmatched	10.342	8.732	1.610	0.199	8.07
		ATT	10.353	9.086	1.267	0.190	6.67
	K-nearest-neighbor	Unmatched	10.342	8.732	1.610	0.199	8.07
		ATT	10.342	8.945	1.397	0.204	6.85
	Caliper	Unmatched	10.342	8.732	1.610	0.199	8.07
		ATT	10.338	8.902	1.436	0.264	5.45
50 or fewer employees	Kernel	Unmatched	8.818	7.018	1.800	0.248	7.24
		ATT	8.773	7.575	1.198	0.256	4.69
	K-nearest-neighbor	Unmatched	8.818	7.018	1.800	0.248	7.24
		ATT	8.773	7.623	1.150	0.270	4.25
	Caliper	Unmatched	8.818	7.018	1.800	0.248	7.24
		ATT	8.773	7.535	1.238	0.325	3.81

Table 13 Treatment effects of R&D tax credits on R&D expenditure: by liquidity constraints

			Treated	Controls	Difference	SE	t-value
Liquidity constraint	Kernel	Unmatched	9.885	7.657	2.228	0.182	12.26
		ATT	9.885	8.419	1.466	0.181	8.09
	K-nearest-neighbor	Unmatched	9.885	7.657	2.228	0.182	12.26
		ATT	9.885	8.488	1.397	0.195	7.17
	Caliper	Unmatched	9.885	7.657	2.228	0.182	12.26
		ATT	9.885	8.413	1.472	0.264	5.57
Non-liquidity constraint	Kernel	Unmatched	9.597	7.874	1.723	0.353	4.88
		ATT	9.383	8.725	0.658	0.358	1.84
	K-nearest-neighbor	Unmatched	9.597	7.874	1.723	0.353	4.88
		ATT	9.383	8.620	0.763	0.379	2.01
	Caliper	Unmatched	9.597	7.874	1.723	0.353	4.88
		ATT	9.383	9.029	0.354	0.597	0.59

Table 14 Tests of matching covariates balancing property: test statistics

		Kernel				K-Nearest Neighbor				Caliper			
		Mean		t-test		Mean		t-test		Mean		t-test	
		Treated	Control	t-value	p-value	Treated	Control	t-value	p-value	Treated	Control	t-value	p-value
ln(total workers)	Unmatched	4.269	2.044	22.030	0.000	4.269	2.044	22.030	0.000	4.269	2.044	22.030	0.000
	Matched	4.292	4.241	0.460	0.649	4.292	4.254	0.350	0.729	4.296	4.096	1.800	0.073
Percentage of indirect workers	Unmatched	5.325	1.626	6.340	0.000	5.325	1.626	6.340	0.000	5.325	1.626	6.340	0.000
	Matched	5.354	5.436	-0.070	0.945	5.354	5.279	0.070	0.948	5.368	4.828	0.480	0.633
Percentage of women workers	Unmatched	28.944	40.698	-5.920	0.000	28.944	40.698	-5.920	0.000	28.944	40.698	-5.920	0.000
	Matched	29.099	28.906	0.110	0.916	29.099	28.344	0.420	0.675	29.096	29.372	-0.150	0.883
Recurring profit margin	Unmatched	4.518	-0.018	0.450	0.651	4.518	-0.018	0.450	0.651	4.518	-0.018	0.450	0.651
	Matched	4.467	3.380	0.880	0.379	4.467	3.612	1.030	0.306	4.433	3.157	1.540	0.125
Dependence on debt	Unmatched	29.035	91.902	-0.600	0.547	29.035	91.902	-0.600	0.547	29.035	91.902	-0.600	0.547
	Matched	29.035	30.113	-0.110	0.914	29.035	26.853	0.860	0.388	28.843	25.913	1.150	0.249
ln(capital fund)	Unmatched	10.521	9.029	19.140	0.000	10.521	9.029	19.140	0.000	10.521	9.029	19.140	0.000
	Matched	10.521	10.591	-0.620	0.538	10.521	10.542	-0.190	0.847	10.528	10.392	1.220	0.223
$D_{1999\text{-}2001}$=1{founded between 1999 and 2001}	Unmatched	0.011	0.049	-2.420	0.016	0.011	0.049	-2.420	0.016	0.011	0.049	-2.420	0.016
	Matched	0.011	0.015	-0.410	0.685	0.011	0.016	-0.450	0.654	0.011	0.016	-0.450	0.654
D_{2002}=1{founded at 2002}	Unmatched	0.005	0.015	-1.090	0.274	0.005	0.015	-1.090	0.274	0.005	0.015	-1.090	0.274
	Matched	0.005	0.007	-0.190	0.849	0.005	0.004	0.150	0.882	0.005	0.005	0.000	1.000
D_{2003}=1{founded at 2003}	Unmatched	0.005	0.015	-1.080	0.280	0.005	0.015	-1.080	0.280	0.005	0.015	-1.080	0.280
	Matched	0.005	0.007	-0.150	0.881	0.005	0.005	0.000	1.000	0.005	0.011	-0.580	0.563
D_{2004}=1{founded at 2004}	Unmatched	0.016	0.015	0.140	0.890	0.016	0.015	0.140	0.890	0.016	0.015	0.140	0.890
	Matched	0.016	0.021	-0.370	0.711	0.016	0.011	0.450	0.654	0.016	0.027	-0.710	0.476
D_{2005}=1{founded at 2005}	Unmatched	0.005	0.013	-0.930	0.350	0.005	0.013	-0.930	0.350	0.005	0.013	-0.930	0.350
	Matched	0.005	0.009	-0.430	0.669	0.005	0.009	-0.370	0.710	0.005	0.005	0.000	1.000
D_{2006}=1{founded at 2006}	Unmatched	0.005	0.009	-0.570	0.569	0.005	0.009	-0.570	0.569	0.005	0.009	-0.570	0.569
	Matched	0.005	0.005	0.050	0.961	0.005	0.003	0.320	0.752	0.005	0.005	0.000	1.000
D_{2007}=1{founded at 2007}	Unmatched	0.005	0.003	0.720	0.469	0.005	0.003	0.720	0.469	0.005	0.003	0.720	0.469
	Matched	0.005	0.002	0.440	0.659	0.005	0.002	0.510	0.613	0.000	0.000	.	.
D_{city}=1{main financing bank is the city bank}	Unmatched	0.543	0.243	9.560	0.000	0.543	0.243	9.560	0.000	0.543	0.243	9.560	0.000
	Matched	0.545	0.538	0.140	0.893	0.545	0.532	0.270	0.788	0.548	0.489	1.140	0.255
D_{local}=1{main financing bank is the local bank}	Unmatched	0.362	0.368	-0.190	0.852	0.362	0.368	-0.190	0.852	0.362	0.368	-0.190	0.852
	Matched	0.364	0.363	0.010	0.990	0.364	0.364	0.000	1.000	0.360	0.376	-0.320	0.748
D_{union}=1{main financing bank is the credit union}	Unmatched	0.053	0.265	-6.580	0.000	0.053	0.265	-6.580	0.000	0.053	0.265	-6.580	0.000
	Matched	0.048	0.053	-0.200	0.842	0.048	0.048	0.000	1.000	0.048	0.070	-0.880	0.381
D_{yugen}=1{set up as a limited company(yugen gaisha)}	Unmatched	0.011	0.393	-10.730	0.000	0.011	0.393	-10.730	0.000	0.011	0.393	-10.730	0.000
	Matched	0.011	0.021	-0.770	0.440	0.011	0.012	-0.100	0.922	0.011	0.016	-0.450	0.654

Table 14 Tests of matching covariates balancing property (contd.)

		Kernel				K-Nearest Neighbor				Caliper			
		Mean		t-test		Mean		t-test		Mean		t-test	
		Treated	Control	t-value	p-value	Treated	Control	t-value	p-value	Treated	Control	t-value	p-value
Construction dummy	Unmatched	0.021	0.047	-1.660	0.098	0.021	0.047	-1.660	0.098	0.021	0.047	-1.660	0.098
	Matched	0.021	0.024	-0.170	0.869	0.021	0.021	0.000	1.000	0.022	0.005	1.350	0.178
Manufacturing dummy	Unmatched	0.809	0.168	23.470	0.000	0.809	0.168	23.470	0.000	0.809	0.168	23.470	0.000
	Matched	0.813	0.803	0.230	0.817	0.813	0.819	-0.160	0.873	0.812	0.828	-0.400	0.687
Information and communications dummy	Unmatched	0.011	0.041	-2.080	0.037	0.011	0.041	-2.080	0.037	0.011	0.041	-2.080	0.037
	Matched	0.011	0.015	-0.370	0.713	0.011	0.012	-0.100	0.922	0.011	0.000	1.420	0.157
Transport and postal activities dummy	Unmatched	0.005	0.100	-4.340	0.000	0.005	0.100	-4.340	0.000	0.005	0.100	-4.340	0.000
	Matched	0.005	0.004	0.200	0.844	0.005	0.003	0.320	0.752	0.005	0.000	1.000	0.318
Wholesale dummy	Unmatched	0.064	0.088	-1.170	0.243	0.064	0.088	-1.170	0.243	0.064	0.088	-1.170	0.243
	Matched	0.064	0.061	0.140	0.887	0.064	0.061	0.130	0.898	0.065	0.065	0.000	1.000
Real estate and goods rental and leasing dummy	Unmatched	0.011	0.092	-3.850	0.000	0.011	0.092	-3.850	0.000	0.011	0.092	-3.850	0.000
	Matched	0.011	0.010	0.080	0.938	0.011	0.004	0.720	0.473	0.011	0.000	1.420	0.157
Private service dummy	Unmatched	0.043	0.042	0.060	0.951	0.043	0.042	0.060	0.951	0.043	0.042	0.060	0.951
	Matched	0.037	0.041	-0.190	0.847	0.037	0.047	-0.460	0.645	0.038	0.054	-0.740	0.458
Accommodations, eating and drinking service dummy	Unmatched	0.005	0.042	-2.500	0.012	0.005	0.042	-2.500	0.012	0.005	0.042	-2.500	0.012
	Matched	0.005	0.006	-0.120	0.901	0.005	0.002	0.510	0.613	0.005	0.000	1.000	0.318
Living-related and personal services and amusement services dummy	Unmatched	0.005	0.157	-5.720	0.000	0.005	0.157	-5.720	0.000	0.005	0.157	-5.720	0.000
	Matched	0.005	0.010	-0.530	0.595	0.005	0.006	-0.130	0.893	0.005	0.011	-0.580	0.563
Other service dummy	Unmatched	0.021	0.048	-1.720	0.085	0.021	0.048	-1.720	0.085	0.021	0.048	-1.720	0.085
	Matched	0.021	0.016	0.370	0.710	0.021	0.017	0.300	0.764	0.022	0.032	-0.640	0.523
Hokkaid dummy	Unmatched	0.005	0.042	-2.520	0.012	0.005	0.042	-2.520	0.012	0.005	0.042	-2.520	0.012
	Matched	0.005	0.005	-0.010	0.995	0.005	0.004	0.150	0.882	0.005	0.000	1.000	0.318
Tohoku dummy	Unmatched	0.016	0.069	-2.890	0.004	0.016	0.069	-2.890	0.004	0.016	0.069	-2.890	0.004
	Matched	0.016	0.018	-0.140	0.885	0.016	0.016	0.000	1.000	0.016	0.000	1.740	0.082
Chubu dymmy	Unmatched	0.106	0.112	-0.250	0.805	0.106	0.112	-0.250	0.805	0.106	0.112	-0.250	0.805
	Matched	0.102	0.103	-0.050	0.962	0.102	0.096	0.170	0.863	0.102	0.070	1.110	0.268
Kinki dummy	Unmatched	0.266	0.158	4.070	0.000	0.266	0.158	4.070	0.000	0.266	0.158	4.070	0.000
	Matched	0.267	0.238	0.650	0.516	0.267	0.245	0.500	0.620	0.269	0.253	0.350	0.724
Chugoku dummy	Unmatched	0.069	0.060	0.520	0.603	0.069	0.060	0.520	0.603	0.069	0.060	0.520	0.603
	Matched	0.070	0.093	-0.840	0.402	0.070	0.079	-0.350	0.724	0.070	0.075	-0.200	0.842
Shikoku dummy	Unmatched	0.011	0.029	-1.530	0.127	0.011	0.029	-1.530	0.127	0.011	0.029	-1.530	0.127
	Matched	0.011	0.015	-0.350	0.724	0.011	0.016	-0.450	0.654	0.011	0.022	-0.820	0.412
Kyushu-Okinawa dummy	Unmatched	0.059	0.095	-1.690	0.091	0.059	0.095	-1.690	0.091	0.059	0.095	-1.690	0.091
	Matched	0.059	0.060	-0.040	0.972	0.059	0.079	-0.770	0.439	0.059	0.113	-1.850	0.065

Table 15 Tests of matching covariates balancing property: joint significance tests

	Before	After		
		kernel	K-Nearest Neighbor	Caliper
Mean of |bias|	35.56	2.23	2.16	5.32
SD of |bias|	46.27	2.20	1.90	4.86
Maximum of |bias|	176.66	9.66	7.65	20.24
Minimum of |bias|	0.44	0.32	0.00	0.00
Pseudo R^2	0.355	0.010	0.012	0.044
LR test p-value	0.000	1.000	1.000	0.675