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Evaluating the Impact of R&D Tax Credits on Innovation: A Microeconometric Study on Canadian Firms*

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Abstract

This study examines the effect of R&D tax credits on innovation activities of Canadian manufacturing firms. Over the 1997-1999 period the Federal and Provincial R&D tax credit programs were used by more than one third of all manufacturing firms and by close to two thirds of firms in high-technology sectors. We investigate the average effect of R&D tax credits on a series of innovation indicators such as number of new products, sales with new products, originality of innovation etc. using a non-parametric matching approach. Compared to a hypothetical situation in the absence of R&D tax credits, recipients of tax credits show significantly better scores on most but not all performance indicators. We therefore conclude that tax credits increase the R&D engagement at the firm level and that the R&D activities induced by fiscal incentives lead to additional innovation output.

Keywords: R&D, Innovation, Public Subsidies, Tax Credit, Policy Evaluation
JEL-Classification: C14, C25, H50, O38

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1 Introduction

Public support for innovation-related activities has been justified in several ways. First, governments are responsible for providing new or improved technology for public sector functions (security, health, and communications) and R&D for these tasks may be performed in public research laboratories or contracted out to private firms and funded by public revenues. The second justification for public subsidies is to correct for market failures resulting from under-investment in innovation activities (cf. Arrow, 1962). Owing to the difficulty that firms have in appropriating all the benefits associated with an innovation, it is argued that private firms invest less in innovation than is "socially desirable". Other often-adduced reasons for public intervention include high, uninsurable risk and a large minimum efficient scale required to introduce major innovations. The theory of public policy based on these factors stresses the need for government to provide incentives to private firms to compensate for the gap between the private and social returns to innovation expenditure (in particular to R&D) in order to ensure the socially optimal supply of research and development effort by the private sector.

In modern economies, the governments apply various policy instruments to foster R&D and innovation in the business sector directly or indirectly. Governments support private investment in R&D by direct grants and by tax credits.[1] In addition to direct R&D grants, Canada has one of the most generous R&D tax-credit programs among major industrial countries. A comparison of the federal government funding of R&D made through the Scientific Research and Experimental Development Investment Tax Credit (SR&ED) program as opposed to direct grant programs indicates that the size of tax credits surpassed grants by 1983 and had reached about 18% of business enterprise intramural R&D expenditures (BERD) by 1989 (see Hanel and Palda, 1992). The share of R&D and innovation related grants peaked at about 7% in 1982 and declined to 1.3% in 2000.[2]

According to the evaluation of the Scientific Research and Experimental Development Investment Tax Credit (SR&ED) program by Finance Canada (1998), the programme was rated as the most important component in the system of government support of R&D followed by refundability of the federal credit, while government grants and contracts received the lowest rating. Between 1988 and 1992, current and capital expenditures eligible for the federal SR&ED tax incentives increased in the case of:

- all corporations, by 50 per cent from $4.5 billion in 1988 to $6.9 billion in 1992
- and smaller CCPCs, by 100 per cent from $0.7 billion in 1988 to $1.4 billion in 1992.

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[1] See OECD (2002) for a recent survey on R&D tax credits in OECD countries.
[2] The ratio of R&D grants to BERD declined from 7.1% in 1982 to 4.2% in 1990 and further to 1.3% in 2000 (see Statistics Canada, 2003: Appendix, Table 19).

In addition to the federal SR&ED tax credit program all provincial and territorial governments provide income tax deductions for research and development. The provinces of Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario and Quebec also offer various types of additional income tax incentives for research and development conducted within their borders. Therefore, the after tax cost of R&D is quite low in Canada. For example, in Ontario, the manufacturing base of Canada, the after-tax cost of $1 of R&D expenditure was 0.507$ in large firms and 0.431$ in small firms in 1996 (see Warda, 1997, for the comparisons between Canadian provinces and Warda, 2001, for an international comparison).

Owing to the administration of the program by fiscal authorities and the confidentiality that surrounds tax-related matters, there is little public information on the distribution of beneficiaries of tax credits. The report by Finance Canada (1998) breaks down recipients of tax credits by the sector of economic activity[3] only, and does not provide details on the use of tax credits by manufacturing industry sub-sectors or groups on a two-digit SIC level. Baldwin and Hanel (2003) provide a detailed description of the distribution and use of tax credits for R&D in the manufacturing sector on basis of the Canadian Survey of Innovation and Advanced Technology conducted in 1993.

According to the most recent Statistics Canada Survey of Innovation 1999 in manufacturing, more than one third of firms (35%) used them in 1997-1999 period. The proportion of tax credit users is highest (65%) among firms in the high technology industries, followed by those in the medium technology sector (41%) and lowest in the low technology sector (26%). Among R&D performing firms, large companies use tax credits more frequently than the medium and small size firms (Hanel, 2003).[4] The tax credit program is also extensively used by R&D performing firms in the primary and service sectors.

In this paper, we evaluate the impact of tax credits for R&D in Canadian manufacturing. The data come from the Statistics Canada Survey of Innovation (1999) that provides information on government support programs for R&D and also some indicators of innovation impact. In contrast to most other studies of R&D credits, ours does not concentrate on the effect of R&D tax credits on private R&D investment (innovation input). Instead, it attempts to evaluate the effect of R&D tax credits on innovation output of firms that used them, e.g. the number of new products, sales with new products, and indicators on the originality of innovations. In a second step of the analysis, we consider a sub-sample of innovating firms and incorporate more general measures of firm performance, like profitability and market share, into the regressions.

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[3] The value of claims by sector in 1992: primary 7%, manufacturing 48%, services 45% (Finance Canada, 1998).
[4] Where small firms have between 20 and 49 employees, medium between 50 and 249 employees and large firms more than 250 employees.

To assess the effect of R&D tax credits, it is important to correct for a possible selection bias in the empirical analysis. For example, estimates from a linear regression model considering the receipt of R&D tax credits as an exogenous variable are likely to be biased, because the recipients of tax credits could differ systematically in several characteristics from non-recipients. The actual recipients might, for example, show more absorptive capacity, be active in more technology-intensive industries, show more succesful innovation activities in the past etc. In this case, even in the hypothetical situation of the absence of a tax credit program, the actual recipients might have shown more innovative activities than actual non-recipients due to their other characteristics driving both the R&D engagement and the probability to receive R&D tax credits. Thus, the mere comparison of recipients and non-recipients leads to biased estimates, and the R&D tax credits have to be considered as an endogenous variable instead. In this paper, we correct for a possible selection bias by using an econometric matching technique as proposed by Heckman et al. (1997, 1998).

The following section briefly reviews the literature on R&D tax credits. Section 3 describes the matching methodology which is used to estimate the effect of tax credits on various innovation indicators at the firm level. Section 4 describes the data used and presents the empirical results. We conclude with the main results and their implication and some ideas for further research in this field.

2 R&D Tax Credits

One central question in the literature on R&D is the effectiveness of governmental market intervention to correct the insufficient supply of R&D. The under investment in R&D occurs due to imperfect appropriability conditions of new knowledge and due to financing gaps induced by asymmetric information (see David et al., 2000, and Hall, 2002 for surveys on both topics). The principal instruments of public support to R&D are direct grants and tax credits. The principal theoretical as well as practical difference between subsidizing R&D by tax credits rather than by a direct grant is that the former is neutral with respect to industry or sector and the nature of the firm. The main attraction of tax credit programs relative to direct grants is that they minimize the discretionary decisions involved in project selection for direct government grants.

Hall and van Reenen (2000) state that tax credits reduce marginal costs of R&D and "crowding out effect on industrial R&D spending is not expected to be affected except via the increase of the real cost of R&D inputs.” Their review of econometric evidence suggest that, indeed, on average a dollar in tax credit for R&D stimulates a dollar of additional R&D. This is also the conclusion of the econometric study of the effectiveness of the Canadian R&D tax credit program by Dagenais et al. (1997) which found that a 1% increase in the federal tax credit generates an average of 98¢ additional private R&D expenditure per dollar of tax revenues forgone. According to Finance Canada (1998), each dollar of tax revenues forgone as a result of the Canadian federal R&D tax incentives generated 1.38 dollars in additional R&D spending. In the present article we do not concentrate our attention on the effect of tax credits on firms' private R&D expenditures. Instead, we analyze the innovation and economic performance of firms that used tax credits.

Even though tax credits are available to all firms for eligible R&D expenditures irrespective of the project or industry sector, according to David et al.(2000), private firms are likely to use any tax credits to first fund projects with the highest private rate of return. For this reason, the authors argue, tax credit users are likely to concentrate on projects with short term prospects. These are not necessarily the projects that would most deserve public support because of the largest gap between the social and private returns (spillover gap). The availability of tax credits is therefore unlikely to increase the probability that the users will undertake projects with high social and low private rate of return. Thus, even though tax credits are an expeditious way distributing public support to R&D and to reduce or eliminate the 'government failure', they do not appear to be the most efficient tool for correction of the 'market failure'. Direct R&D grants are potentially better suited to bridge the gap between the private and social returns to innovation but this comes at a cost. The discretionary power given to government agencies selecting projects worthy of public support may cause a 'government failure' as large or even larger than the 'market failure' it is supposed to correct.

Although we recognize the importance of this dilemma, we can not address it in the present paper. Our objective is more modest. We attempt to answer three closely related research questions focusing exclusively at the effect of R&D tax credits. First, do R&D tax credits increase the proportion of firms that perform R&D? Second, knowing that the importance of the R&D input to innovation is increasing with the originality of innovation, do firms that use R&D tax credits introduce more frequently the more original Canadian and world-first innovations than other firms? Third, are the users of tax credits on average performing better on a series of economic indicators than the non-users?

The microeconomic evidence regarding the effect of tax credits on firms' performance is rather limited. Studies that examined the effect of government support on output measures: for example, on patent applications, productivity, returns on capital, returns on sales and growth of sales or employment (see Klette et al., 2000, for a survey) did not consider the effects of tax credits.

Hanel (2003), using the same data as the present study, found that firms that used R&D tax credits in Canada are more likely introduce the most original world-first innovations than firms introducing less original ones. The originality counts because, according to Cozzarin (2004), in Canada the world-first innovators display superior performance. It is not clear, however, if this is so because the bigger firms with large market share and superior labor productivity tend to introduce more frequently original world-first innovations or the other way round. Cozzarin's conclusions are also at difference with results of an earlier innovation survey. Firms with the most original innovations did not report that the innovation had improved their domestic market share and profitability as frequently as firms that introduced the less original Canada-first or 'other' imitative innovations. Only in export performance were the world-first innovations superior to the less original ones (Baldwin and Hanel, 2003).[5] This raises the empirical question whether, in general, performance of firms that use tax R&D credits differs from that of non-users and whether the superior performance can be attributed to the effect of R&D tax credits.

3 Estimation of Treatment Effects with the Matching Estimator

The modern econometric evaluation techniques have been developed to identify treatment effects when the available observations on individuals or firms are subject to a selection bias. This typically occurs when participants in public measures differ from non-participants in important characteristics. Popular economic studies are on the benefit of active labor market policies.

The literature on the econometrics of evaluation offers different estimation strategies to correct for selection bias (see Heckman et al., 1997, Heckman et al. 1999 for a survey) including the difference-in-difference estimator, control function approaches (selection models), IV estimation and non-parametric matching. The difference-in-difference method requires panel data with observations before and after/while the treatment (change of subsidy status). As our database (to be described in the following subsection) consists of a cross-section, we cannot apply this estimator. For the application of IV estimators and selection models one needs valid instruments for the treatment variables. It is very difficult in our case to find possible candidates being used as instruments. Hence, the only appropriate choice is the matching estimator. Its main advantage over IV and selection models is that we neither have to assume any functional form for the outcome equation nor is a distributional assumption on the error terms of the selection equation and the outcome equation necessary. The disadvantage is that it does only control for observed heterogeneity among treated and untreated firms.

Matching estimators have recently been applied and discussed by Angrist (1998), Dehejia and Wahba (1999), Heckman et al. (1998a, 1998b), and Lechner (1999, 2000). Almus and Czarnitzki (2003) as well as Duguet (2004) employ the matching methodology in the context of public R&D grants in Germany and France. The matching is able to address directly the question "What would a treated firm with given characteristics have done if it had not been treated?" A treatment in our context is the receipt of R&D tax credits. Those observations on treated firms are compared with non-treated firms, but not with all non-recipients but a selected group with similar characteristics. Our fundamental

[5] The Survey of Innovation and Advanced Technology analyzed by Baldwin and Hanel (2003) provides respondents' evaluation of the effect of their firms' most profitable innovation introduced in the 1989-1991 period on domestic and foreign market shares, profitability and other performance indicators. Note the subtle difference in the data between the 1993 and 1999 Innovation surveys. Respondents to the Survey of innovation 1999 related the performance indicators <u>to all innovations</u> introduced by the firm. In contrast, respondents to the 1993 provided the information on a <u>specific, most profitable innovation</u>.

evaluation question can be illustrated by an equation describing the average treatment effect on the treated individuals or firms, respectively:

$$E\left(\alpha_{TT}\right)=E\left(Y^{T} \mid S=1\right)-E\left(Y^{C} \mid S=1\right) \tag{1}$$

where Y^T is the outcome variable. We will consider various measures of innovation in the subsequent empirical analysis. The status S refers to the group: S=1 is the treatment group and S=0 the non-treated firms. Y^C is the potential outcome which would have been realized if the treatment group (S=1) had not been treated. The problem is obvious: while the outcome of the treated individuals in case of treatment, $E(Y^T|S=1)$, is directly observable, it is not the case for the counterpart. What would these firms have realized if they had not received the treatment? $E(Y^C|S=1)$ is a counterfactual situation which is not observable and, therefore, has to be estimated. In the case of matching, this potential outcome of treated firms is constructed from a control group of firms that did not receive R&D tax credits. The matching relies on the intuitively attracting idea to balance the sample of program participants and comparable non-participants. Remaining differences in the outcome variable between both groups are then attributed to the treatment (Heckman et al., 1997).

Initially the counterfactual cannot simply be estimated as average outcome of the non-participants, because $E(Y^C|S=1) \neq E(Y^C|S=0)$ due to the possible selection bias. The participant group and non-participant group are expected to differ, except in cases of randomly assigned measures in experimental settings. Rubin (1977) introduced the conditional independence assumption (CIA) to overcome the selection problem, that is, participation and potential outcome are independent for individuals with the same set of exogenous characteristics X. Thus, the critical assumption using the matching approach is whether we can observe the crucial factors determining the entry into the programme. If this assumption is valid, it follows that

$$E\left(Y^{C} \mid S=1, X\right)=E\left(Y^{C} \mid S=0, X\right) \tag{2}$$

The outcome of the non-participants can be used to estimate the counterfactual outcome of the participants in case of non-participation provided that there are no systematic differences between both groups. The treatment effect can be written as

$$E\left(\alpha_{TT}\right)=E\left(Y^{T} \mid S=1, X=x\right)-E\left(Y^{C} \mid S=0, X=x\right) \tag{3}$$

Conditioning on X takes account of the selection bias due to observable differences between participants and non-participants. In our case, we conduct a Nearest Neighbor matching, that is, for each treated firm we pick the most similar firm from the potential control group of non-subsidized firms.[6] In addition to the CIA, another important precondition for consistency of the matching estimator is common support, i.e. it is necessary that the control group contains at least one sufficiently similar observation for each treated firm. In practice, the sample to be evaluated is restricted to common support. If the overlap between the samples is too small the matching estimator is not applicable.

Table 1: The matching protocol

Step 1	Specify and estimate a probit model to obtain the propensity scores $\hat{P}(X)$.
Step 2	Restrict the sample to common support: delete all observations on treated firms with probabilities larger than the maximum and smaller than the minimum in the potential control group. (This step is also performed for other covariates that are possibly used in addition to the propensity score as matching arguments.)
Step 3	Choose one observation from the subsample of treated firms and delete it from that pool.
Step 4	Calculate the Mahalanobis distance between this firm and all non-subsidized firms in order to find the most similar control observation. $MD_{ij} = \left(Z_j - Z_i\right)' \Omega^{-1} \left(Z_j - Z_i\right)$, where Ω is the empirical covariance matrix of the matching arguments based on the sample of potential controls. If only the propensity score is used, there is no need to calculate a multidimensional distance. In that case, e.g. a Euclidian distance is sufficient.
Step 5	In this application of the matching, we restrict the group of potential neighbors to firms active in the same industry as the particular treated firm. Select the observation with the minimum distance from the remaining sample. (Do not remove the selected controls from the pool of potential controls, so that it can be used again.)
Step 6	Repeat steps 3 to 5 for all observations on subsidized firms.
Step 7	Using the matched comparison group, the average effect on the treated can thus be calculated as the mean difference of the matched samples: $\hat{\alpha}_{TT} = \frac{1}{n^T}\left(\sum_i Y_i^T - \sum_i \hat{Y}_i^C\right)$ with $\hat{Y}_i^C$ being the counterfactual for i and n^T is the sample size (of treated firms).

As one often wants to consider more than one matching argument, one has to deal with the "curse of dimensionality". If we employ a lot of variables in the matching function, it will become difficult to find appropriate controls. Rosenbaum and Rubin (1983) suggested to use a propensity score as a single index and thus to reduce the number of variables included in the matching function to just one. Therefore a probit model is estimated on the dummy indicating the receipt of subsidies *S*. The estimated propensity scores are subsequently used as matching argument. Lechner (1998) introduced a modification of the propensity score matching ("hybrid matching") as one often wants to include additional variables, e.g. like firm size, directly in the matching function. In this case, instead of a single *X* (the propensity score), other important characteristics may be employed in the matching function. The

[6] Other matching estimators are, for example, caliper matching or kernel matching (see Heckman et al., 1999).

matching protocol in Table 1 summarizes the empirical implementation of the matching procedure used in this paper. We use sampling weights throughout the whole analysis. Thus the calculations presented in the empirical analysis represent population figures rather than sample results. The estimated treatment effects on the treated, thus, account for all tax credit recipients in the population, and not only the sampled firms.

4 Data and Empirical Concept

This analytical study is based on data from the Canadian 1999 Survey of Innovation which was conducted by the Science, Innovation and Electronic Information Division of Statistics Canada. A representative sample of 5,944 provincial-enterprises[7] in manufacturing has been produced.

The survey design can be described as a stratified random sample by industry and by location (12 Canadian provinces or territories). The survey provides sampling weights permitting estimates for the firm population. The sampling weights are used throughout the whole analysis. The frame was the ASM (Annual Survey of Manufactures). The population considered was all provincial enterprises (both single and multi-establishment provincial enterprises) with at least 20 employees and at least $250,000 in annual revenues, according to the business register (June 1997 version). The response rate for the survey was 95% based on 5,455 completed questionnaires. The total population was 9,303 provincial enterprises in manufacturing.

The survey collected information on topics such sources of information for innovation, problems and obstacles to innovation, impact of innovation, cooperative and collaborative arrangements for innovation, competitive environment, business success factors, intellectual property protection, and use of government support programs.

There are two scenarios for the empirical analysis: As Czarnitzki (2002) points out, the public incentives may have two different impacts on innovative activity. In the case, public funding does indeed stimulate private investment, the question "what had the firms done in the absence of public support for R&D" has two facets. On one hand, the level of private R&D investment of the recipient firms might simply have been lower. On the other hand, firms, especially small and medium sized firms, might have not undertaken any R&D activities without public support due to lacking financing opportunities. The first scenario aims at the marginal increase of R&D investment among innovating firms,

[7] The unit "Provincial-enterprise" consists of all establishments of a given enterprise in the same (4-digit NACE) industry within the same province. Details of the survey design and sample methodology are available in Schaan and Nemes (2004).

and the latter one at the overall R&D status. These two hypotheses lead us to following set-up of our upcoming empirical analysis:

- In our first estimation, the potential control group consists of all firms, that is, innovating and non-innovating firms which did not receive R&D tax credits. Consequently, we allow that recipient firms may not have conducted any innovation activity in the absence of public support.
- In a second step, we restrict the potential control group to innovating firms in order to check the robustness of the previous estimation. On one hand, this will indicate whether the first results were only driven by non-innovators. On the other hand, the treatment effects are likely to be underestimated, as we do not allow firms to change their status from innovation to non-innovation due to the absence of public support. In this second estimation, we also consider some additional outcome variables. These are questions on general improvements of firm performance due to innovation. Those measures are only considered in the innovators' sample, because the corresponding survey questions are asked conditional on the introduction of new products and processes in the questionnaire.

Some readers might ask whether the application of an econometric matching is the appropriate approach to our evaluation problem. As the R&D tax credit is basically available to every firm conducting R&D, it may be questioned, on the one hand, whether companies that did not use the SR&ED program form a valid potential control group. First, even though the tax credit has been around for long time, some firms may still not be aware of its existence or of the potential advantages they could obtain from using it. Second, it is a well-known fact that a fair amount of firms is reluctant to apply for tax credits, despite being eligible to do so. Smaller firms spending only few resources on R&D or conducting R&D only on an occasional basis may well refrain from claiming tax credit due to the perception that it involves considerable extent of bureaucracy faced in filling out the necessary forms etc. Third, the use of R&D tax credits may increase the probability of audits of a firm's accounts by the taxation authorities, even in other areas of the business aside of R&D activities. This may also result in reluctance of claiming tax credits. In those cases, the potential control group would contain firms that conduct a significant amount of R&D activities. If the control group would be entirely different from the R&D tax credit recipients, one would hardly find R&D performing firms that did not use tax credits. As a matter of fact, our potential control group contains a fair number of firms showing R&D activities. For example, 483 firms (about 16% of the control group) maintain an own R&D department and 300 firms (10%) use to contract out R&D (see descriptive statistics in Table 2 in the subsequent section). Therefore, we assume that firms not using R&D tax credits form a valid potential control group. This is also supported by the upcoming matching analysis, because we find a broad common support for the treatment group, i.e. for most tax credit recipients the control group contains sufficiently similar firms that did not use tax credits, and can thus be picked as nearest neighbors.

4.1 Description of the database

The initial sample of 5,455 observations reduced to 4,644 observations which are used in this study due to several reasons. The considered firm population of the survey takes firms with at least 20 employees into account. However, several firms (223 obs.) that responded had less than 20 employees. These are dropped from the analysis. Furthermore, some companies are exceptionally large. As such firms are unique in the Canadian economy, it would not be meaningful to search for comparable firms within the matching analysis. Thus, we decided to exclude firms with more than 1,500 employees from the upcoming empirical study (74 obs.). Furthermore, it is important to note that some firms of the initial sample of the survey have received venture capital from the Government (163 observations). We exclude those firms from our analysis because venture capital is a special source of public finance and may influence its recipients strongly. Finally, other observations of the remaining sample could not be used due to inconsistent responses or missing values in the questionnaire. The sampling weights of those observations dropped due to inconsistent responses or missing values were taken into account by re-adjusting the weights of the usable sample in the respective strata.

4.1.1 Treatment Indicator

The treatment indicator is a dummy variable called *GVTTAX* that has unit value if a firm received R&D tax credits from the Canadian Federal Government or from provincial governments, and *GVTTAX* is zero otherwise. The sample used amounts to N^1=1,646 recipient firms and to N^0=2,998 firms in the potential control group. Another instrument of public support is R&D grants. Firms can apply for those public grants to receive governmental support for particular research projects. Besides very few exceptions, all firms that received public R&D grants have also claimed R&D tax credits. Thus, the group of treated firms in our analysis contains a subset of firms that has received both R&D tax credits and public R&D grants.[8]

4.1.2 Control variables

We use several variables that describe the firms' characteristics. The number of employees account for size differences, and is specified in logarithms, *LNEMP*. An important feature of firms regarding R&D tax credits is how they organize their innovation activities. We include various measures to capture the firm behavior concerning innovation: A dummy variable *RDDEP* indicating that a firm maintains its own R&D department is an important criterion to differentiate between firms that conduct R&D permanently from others that undertake R&D occasionally or not at all. Firms with an own R&D depart-

[8] We also ran the upcoming analysis excluding firms that received grants from the treatment group. The results, however, were very similar and did not change our conclusions. Therefore, we chose not to present these estimations in more detail.

ment claim most likely tax credits because research activities are well organized in an separate department of the firm. Moreover, a dummy *RDCONTR* denotes firms that contract out (some of) their R&D activities. It is a-priori unclear how this variable influences the propensity to claim tax credits. On one hand, the firms may not conduct own research activities if R&D is contracted out. In this case, the expected sign of *RDCONTR* would be negative. On the other hand, firms that contract-out R&D may be well organized and conduct a lot of R&D on their own, but use external knowledge resources to supplement their skills. We would expect that those highly technology oriented firms are more likely to receive tax credits than others.

In addition, we consider other indicators that describe the firms' orientation towards innovation. Czarnitzki and Kraft (2004) show that firms challenging new markets invest more in R&D than incumbent firms. Therefore, we construct a variable that identifies market challenging firms. An indicator variable *NEWMT* takes unit value for firms indicating that either seeking new markets or developing nice or specialized markets is an important aim of the firms business strategy. *NEWMT* is zero otherwise. A positive sign is expected if the results of Czarnitzki and Kraft hold for the Canadian case; challenging firms are considered to be more innovative than others and are therefore more likely to receive R&D tax credits.

As the Canadian Innovation Survey consists only of one cross-section, it is difficult to control for previous R&D activities of the firms. These may be an important determinant of the likelihood to receive tax credits, because firms that conducted R&D in the past should be more experienced than other ones. Unfortunately, no direct information on previous R&D or innovation activities is available with this survey. However, the data for the price-cost margin - a good proxy for profits - is available. According to the Schumpeterian hypothesis one would expect that large firms in concentrated industries with history of ongoing R&D and innovation activities are likely to achieve higher price-cost margins. Hanel and St-Pierre (2002) found that even when controlling for industry concentration and firm size, firms with higher stock of R&D per sales report higher profitability in subsequent years. Thus firms with a high price-cost margin are more likely than other firms to have a history of cumulative R&D and innovation experience. In contrast, firms with higher price-cost margin are more likely to have financial resources for internal funding of R&D projects. The empirical evidence suggests that internal funding is the preferred way of financing R&D and innovation projects (see e.g. Harhoff, 1998, Hall, 2002, Carpenter and Peterson, 2002, and for Canada Baldwin and Hanel, 2003). The price-cost margin (*PCM*) is constructed as suggested by Collins and Preston (1969) and Ravenscraft (1983), and the data is from the "Annual Survey of Manufacturers 1997" which is linked to the Innovation Survey:[9]

[9] Note that this empirical approximation of the price-cost margin does not take cost of capital into account.

$$PCM_i = \left[\text{Shipments}_i - \left(\text{Staff Cost} + \text{Fuel\&Energy} + \text{Materials}\right)_i\right] / \text{Shipments}_i \quad .$$

The argument on the importance of internal resources goes hand in hand with the "Neo-Schumpeter Hypothesis II" which argues that firms in more concentrated industries realize a higher producer's surplus and that those higher margins enable the respective firms to invest more into innovation activities. The sign of the coefficient of *PCM* in the selection equation is a priori unclear, though. It would be negative if firms with scarce internal resources seek financing opportunities for R&D, and are therefore more likely to claim tax credits. As, however, the tax credit is only granted if R&D has been undertaken, we could expect that firms with higher internal resources spend more on privately funded R&D activities and are thus more likely to receive tax credits. *PCM* enters the regression as a lagged variable and thus reflects the financial resources of the firm prior to the tax credit period under review, this avoids endogeneity problems with current R&D activities that might contribute positive to producer's surplus.

Furthermore, we include in the regression the intensity of R&D expenditures per dollar of sales at the industry level (*INDRD*). It reflects industry-specific technological opportunities. Firms in industries with higher technological opportunities are expected to be more innovative, and thus more likely to claim tax credits. Like *PCM* this variable is lagged in order to avoid endogeneity problems.

In addition to the control variables mentioned above, 12 industry dummies enter the regression in order to control for different industry characteristics that are not yet captured by other factors. Moreover, the provincial R&D tax credit incentives differ. For this reason, geography is taken into account by four dummies for Canadian regions identifying firms located in Ontario, Quebec, the Atlantic region (Newfoundland; Prince Edward Island; Nova Scotia and New Brunswick), British Columbia and the Prairie region (Manitoba; Saskatchewan and Alberta).

4.1.3 Outcome variables

The survey offers a variety of potential outcome variables. First, we choose variables describing the innovativeness of the firms and, second, impacts of recent R&D on innovative output. Third, we consider general performance indicators like profitability and market power. These are, however, only considered in the second part of the analysis (the subsample of innovating firms), because the items are surveyed in the questionnaire conditional on recent innovations.

One of the main objectives of R&D tax credits is to induce firms to start performing R&D and innovate, as the R&D tax credits reduce the cost of research and development. It may well be the case that some firms conduct R&D due to public incentive. We therefore estimate how many of the recipient firms would have conducted R&D had they not received tax credits. The dummy variable *RDCON* indicates firms conducting R&D activities.

As output indicators, we first consider two dummy variables indicating whether the particular firm introduced a new product or process that was a world novelty (*WFIRST* = 1; zero otherwise) or new to the Canadian economy (*CAFIRST* = 1; zero otherwise), respectively. Note that a "world first" innovation is also a "Canada first" innovation by construction. These variables indicate whether radical inventions have been developed, which is supposed to be superior to incremental innovations in our understanding. Thus we interpret possible positive effects of the R&D tax credits on those dummy variables as an increase in quality of innovations (due to intensified R&D activities). The variables *NEWPROD* and *NEWSALES* also consider the output side of the innovation process. *NEWPROD* measures the number of new or significantly improved products, and has ordinal scale taking values from 0 to 6. Let *NEWPROD** represent the number of new or significantly improved products. We observe[10]

$$NEWPROD = \begin{cases} 0 \text{ if } NEWPROD^* = 0 \\ 1 \text{ if } NEWPROD^* \in [1,2] \\ 2 \text{ if } NEWPROD^* \in [3,5] \\ 3 \text{ if } NEWPROD^* \in [6,10] \\ 4 \text{ if } NEWPROD^* \in [11,20] \\ 5 \text{ if } NEWPROD^* \in [21,50] \\ 6 \text{ if } NEWPROD^* > 50 \end{cases}$$

Similarly the variable *NEWSALES* indicates the share of new sales from new products (or goods or services) introduced between 1997 and 1999. It has ordinal scale and we observe

$$NEWSALES = \begin{cases} 0 \text{ if } NEWSALES^* = 0\% \\ 1 \text{ if } NEWSALES^* \in [1\%,5\%] \\ 2 \text{ if } NEWSALES^* \in [6\%,15\%] \\ 3 \text{ if } NEWSALES^* \in [16\%,25\%] \\ 4 \text{ if } NEWSALES^* \in [26\%,50\%] \\ 5 \text{ if } NEWSALES^* \in [51\%,75\%] \\ 6 \text{ if } NEWSALES^* \in [76\%,100\%] \end{cases}$$

In contrast to the technological output indicated by *WFIRST, CAFIRST, NEWPROD*, the variable *NEWSALES* expresses the economic success of the newly introduced products as evaluated by the market. Whereas the first three measures assess if something "new" with respect to technological developments has been created, *NEWSALES* accounts for the economic value of these inventions. Note, however, that it only reflects product innovations. Cost reductions due to the introduction of new

[10] These threshold values for the different categories stem from the questionnaire of the innovation survey.

processes may even be more important than product innovations in mature industries. Unfortunately the survey contained no direct questions on the rate of cost reductions.

As described above, we consider a subsample of innovation firm in a second step of the analysis. For this case, we employ some additional variables on firm performance. This is only meaningful in the subsample of innovating firms, as those performance indicators are survey questions conditional on innovations that have actually taken place. The question asks "What impact did new or significantly improved products (goods or services) and new significantly improved production/manufacturing processes [...] have on your firm?" The opinions of the interviewees are measured in a five-scale variable from value 1 indicating "strongly disagree" to value 5 "strongly agree". We transform the original five scale variables into dummy variables indicated whether the interviewee indicated "strongly agree" or not. In particular, we consider following impacts of recent innovations (dummy variables):

- "Increased the profitability of your firm" ➔ *Profitability*
- "Increased your firm's domestic market share" ➔ *Domestic market share*
- "Increased your firm's international market share" ➔ *International market share*
- "Allowed your firm to keep up with its competitors" ➔ *Keep up with competitors*

4.2 Estimation results using the full sample

Table 2 displays the mean values for all variables of R&D tax credits recipients and non-recipients in the full sample. Note that all means differ between both groups on the 1% significance level. For example, recipient firms are larger. Whilst firms in the treatment group have about 104 employees (*LNEMP* = 4.64), on average, firms in the potential control group show 76 employees (*LNEMP* = 4.337). Moreover, almost 50% of the recipient firms maintain an own internal R&D department, while only 16% of the other firms do so. Furthermore, 31% of the tax credit recipients contract out (some) R&D, but only 10% from the other firms. The approximation of the price-cost margin amounts to 26% in the treatment group, whereas it is only 24.2% in the potential control group.

Recipient firms also perform better in terms of innovation outcome (outcome variables), e.g. they achieve more product innovations and higher shares of sales with new products. Additionally, they are more likely to introduce market novelties: 17% introduced a world-first innovation to the market, whilst only 5% of the other firms did so. Same is true for Canada-first innovations, where the shares amount to 40% versus 16%.

The main research question in this paper is whether differences in outcome variables between the groups can (partly) be assigned to the fact of the R&D tax credits and thus public policy incentive schemes. The systematic differences in control variables between both groups suggest that tax credit recipients are substantially different from the control group. However, a simple comparison of means suffers from a potential sample selection bias. The upcoming matching analysis attempts to correct for this selection bias and investigates whether tax credit users introduce more original innovations and have on average better performance indicators due to the fact of the tax credit receipt. Therefore, a selected group of non-users is constructed that is similar to the treatment group in various covariates. In the case that the innovation outcome variables still differ between these two groups significantly, one can assign this difference to the use of tax credits.

Table 2: Mean differences between R&D tax credit recipients and potential control group (full sample)

	GVTTAX = 1 N^1 = 1,646		*GVTTAX* = 0 N^0 = 2,998		p-value of two-tailed t-test on mean difference
Variable	Mean	Std. Err.	Mean	Std. Err.	
			Covariates		
LNEMP	4.640	0.025	4.337	0.016	p < 0.001
RDDEP	0.496	0.014	0.161	0.007	p < 0.001
RDCONTR	0.312	0.013	0.100	0.006	p < 0.001
NEWNT	0.916	0.007	0.837	0.008	p < 0.001
EXPMT	0.693	0.013	0.532	0.011	p < 0.001
PCM (lagged)	0.260	0.004	0.242	0.003	p < 0.001
INDRD (lagged)	1.777	0.057	1.148	0.021	p < 0.001
Propensity Score	0.496	0.006	0.235	0.003	p < 0.001
			Outcome variables		
RDCON	1.000	0	0.421	0.010	p < 0.001
NEWPROD	2.456	0.044	1.507	0.035	p < 0.001
NEWSALES	1.969	0.038	1.187	0.028	p < 0.001
WFIRST	0.171	0.010	0.048	0.004	p < 0.001
CAFIRST	0.398	0.013	0.159	0.007	p < 0.001

Note: All statistics are computed using sampling weights and represent the respective population moments. Industry and province dummies are not presented. The means of those variables differ significantly among groups, too.

As described in Section 3, we employ an econometric matching to assess the causal effect of the "treatment" with R&D tax credits. Therefore, we initially estimate the propensity score of receiving R&D tax credits using a probit model. The regression takes sampling weights into account.

The larger the firm the more likely it is to use R&D tax credits. This positive relationship between the tax credit dummy and firm size fits well into the "Neo Schumpeter Hypothesis I", which states that innovation activity increases with firm size due to fixed cost degression leading to lower average cost. Firms that maintain an own R&D department are clearly more likely to use tax credits. This is not very surprising, as an own R&D department indicates that such firms pursue innovation activities permanently and that they are an important element within the general firm strategy. Such firms are more organized in performing R&D and are, thus, more likely to use tax credits. Similarly, tax credit users contract R&D out more frequently than non-users, because firms active in R&D have a higher absorptive capacity and complement rather than substitute their own research by contracting out specific tasks. Firms that challenge new markets or seek niches are more likely to receive tax credits. This is in line with the findings of Czarnitzki and Kraft (2004) who show that market-challenging firms are more innovative than others. The price-cost margin *PCM* shows a positive impact on the use of tax credits. According to the financial constraints literature and the Neo-Schumpeter Hypothesis II innovation activity increases with profitability. This effect seems to be translated into an increased utilization of R&D tax credits as well. Firms that realize only low or even negative returns may not be able to conduct R&D activities due to financing difficulties in general, and can thus not claim tax credits.

Table 3: Probit model on the tax credit dummy (sampling weighted regression)

	Coefficient	t-value
LNEMP	0.154 ***	5.78
RDDEP	0.795 ***	14.79
RDCONTR	0.594 ***	9.37
NEWNT	0.266 ***	3.45
EXPMT	0.263 ***	5.21
PCM (lagged)	0.337 **	2.07
INDRD (lagged)	0.031 ***	2.59
Constant term	-1.983 ***	-10.84
Log-Likelihood	-2,265.55	
McFadden R-squared	0.223	
Number of observations	4,644	

Note: *** (**, *) indicate a 1% (5, 10%) significance level. The regression includes 12 industry dummies and four regional dummies (not presented).

The estimated propensity score is used to balance the samples, i.e. the potential control firms that show the most similar probability to receive tax credits are selected in order to construct the counterfactual situation for the tax credit receipients as described in Section 3. The mean of the estimated propensity score in Table 2, shows that the likelihood to receive tax credits is significantly different among groups before the matching, on average.

It turned out that the best results - in terms of balancing the samples according to the covariates – are achieved if we restrict potential nearest neighbors to the group of firms that is active in the same industry as the respective R&D tax credit recipient. Moreover, we took regional factor into account not only in the estimation of the propensity score, but also in the Mahalanobis distance. Instead of the province dummies, we just used the sampling weights of observations as a matching argument. This setting ensures that the treatment group and the selected control group represent a similar fraction of the firm population. Note that it is still possible that a selected control observation is from a different region (sampling weight appears in the Mahalanobis distance) if it is very similar to a treated firm in the other characteristics. However, a necessary condition is that it has to be from the same industry (this restriction is imposed after the calculation of the Mahalanobis distance; see Table 1).

As outlined in Section 3, it is necessary to restrict the sample to common support. In our case, it implies that for each treated firm, there must be a potential control observation with a similar propensity score stratified by industry and region. We calculate the minimum and maximum of the propensity scores of the potential control group by industry and region. It turns out that for 173 observations of the treatment group, we do not have adequate equivalents in the control group. These 173 observations have to be excluded from the following matching process. Typically these treated firms are active in small industries in small regions. As the lost observations only amount to less than 4% of the sample, we do not think that this restriction affects the results in a significant way.

Table 4 shows the mean values of all variables after the matching and the results of two-tailed t-tests on mean differences are presented. The estimated treatment effects are the mean differences of the dependent variables (lower part of the variables' list) between groups. It turns out that the matching is successfully performed, because the groups do not differ in the estimated propensity score and the covariates, on average.

Table 4: Mean differences between R&D tax credit recipients and selected control group after the matching (full sample)

	GVTTAX = 1 N^1 = 1,473		*GVTTAX* = 0 N^0 = 1,473		p-value of two-tailed t-test on mean difference
Variable	Mean	Std. Err.	Mean	Std. Err.	
			Covariates		
LNEMP	4.600	0.026	4.617	0.025	$p = 0.568$
RDDEP	0.460	0.014	0.460	0.014	$p = 0.916$
RDCONTR	0.277	0.013	0.253	0.012	$p = 0.192$
NEWNT	0.917	0.008	0.913	0.008	$p = 0.697$
EXPMT	0.681	0.013	0.686	0.013	$p = 0.801$
PCM (lagged)	0.258	0.004	0.254	0.004	$p = 0.536$
INDRD (lagged)	1.712	0.062	1.592	0.049	$p = 0.126$
Propensity Score	0.476	0.007	0.470	0.007	$p = 0.494$
			Outcome variables		
RDCON	1.000	0	0.708	0.013	$p < 0.001$
NEWPROD	2.425	0.047	2.133	0.054	$p < 0.001$
NEWSALES	1.966	0.041	1.556	0.038	$p < 0.001$
WFIRST	0.166	0.011	0.076	0.008	$p < 0.001$
CAFIRST	0.395	0.014	0.243	0.012	$p < 0.001$

Note: All statistics are computed using sampling weights and represent the respective population moments. Industry and province dummies are not presented. The distribution of observations over industries is identical in the treatment group and the control group and it does not differ significantly among regions.

However, we still find differences in the outcome variables. Hence, we can assign such differences to the fact of the treatment. First, as the difference of the mean value of the variable *RDCON* between the two groups shows, we estimate that almost one third (about 29%) of firms that used R&D tax credits would not have conducted R&D in the absence of this program. Therefore, we conclude that policy incentives have a positive impact on the R&D activity of firms.

As the variables *NEWPROD* and *NEWSALES* show, the treatment does also yield positive effects in terms of the number of product innovations as well as product innovations weighted by their economic value (the share of sales). Hence, we can conclude that treated firms do not only conduct more R&D, but that the induced R&D due to the received tax credits has an additional output effect. However, the differences are difficult to interpret as those variables have ordinal scale. Strictly speaking, it is not even valid to compute the average differences for ordinal variables. In order to overcome at least the latter problem, we also calculated non-parametric median tests which are valid for ordinal variables. Such tests support the findings using the average values, too. Finally, it turns out that the recipient firms are actually more likely to introduce a world-first and Canada-first innovation – compared to the counterfactual situation, that is, in absence of R&D tax credits. About 17% (40%) of tax credit recipient firms introduced a world-first (Canada-first) innovation. If they had not received a tax credit, this figures had only been 8% (24%), see Table 4.

4.3 Estimation results using the innovators' subsample

As pointed out above, our second step of the analysis considers only innovating firms, i.e. firms that did not innovate are excluded from the sample. Rather than 2,998 observations (full sample), the potential control group comprises of 2,269 innovating firms in this case. Innovators are those firms that at least introduced one new product or process in the period of 1997-1999. Note that a few observations of the treatment group are lost, too, because those firms have used R&D tax credits, but did not indicate that they introduced a product or process in the respective period. The size of the treatment group reduces from 1,646 to 1,576 observations. On one hand, the innovation process might still be pending. On the other hand, it could just have been unsuccessful. In any case, these are only a few observations (about 4% of the treatment group) and given our large sample size, excluding them should not affect results significantly. Again, we estimate a probit model to obtain the estimated propensity scores using the same specification as above. We omit the detailed presentation of the probit estimates, because they are quite similar to the previous ones. Like in the full sample, all covariates (as presented in Table 3) are positive and significantly different from zero.

Table 5 shows the variables' means of the treatment group and the potential control group before the matching process. Although we only consider innovating firms, the groups still differ significantly in all covariates. The statistics also indicate that the tax credit recipients show a better performance in the dependent variables *RDCON*, *NEWPROD, NEWSALES, WFIRST*, *CAFIRST*. However, the measures on general firm performance only included in this second step of the analysis do not show such a clear picture. The means of variables reflecting the impact of recent innovations on profitability and the dometic market share are not significantly different between both groups. Only the increase in international market share and the "keeping up with competitors" are significantly different at the 5% level, on average.

Table 5: Mean differences between R&D tax credit recipients and potential control group (subsample of innovating firms)

Variable	*GVTTAX* = 1 N^1 = 1,576 Mean	Std. Err.	*GVTTAX* = 0 N^0 = 2,269 Mean	Std. Err.	p-value of two-tailed t-test on mean difference
			Covariates		
LNEMP	4.643	0.025	4.386	0.019	$p < 0.001$
RDDEP	0.504	0.014	0.196	0.009	$p < 0.001$
RDCONTR	0.316	0.013	0.123	0.007	$p < 0.001$
NEWNT	0.922	0.007	0.877	0.009	$p < 0.001$
EXPMT	0.698	0.013	0.532	0.012	$p < 0.001$
PCM (lagged)	0.261	0.004	0.244	0.003	$p < 0.001$
INDRD (lagged)	1.802	0.059	1.165	0.024	$p < 0.001$
Propensity Score	0.521	0.006	0.283	0.004	$p < 0.001$
			Outcome variables		
RDCON	1.000	0	0.512	0.012	$p < 0.001$
NEWPROD	2.560	0.044	1.988	0.040	$p < 0.001$
NEWSALES	2.053	0.038	1.566	0.032	$p < 0.001$
WFIRST	0.176	0.010	0.061	0.006	$p < 0.001$
CAFIRST	0.412	0.014	0.205	0.010	$p < 0.001$
			General performance variables		
Profitability	0.208	0.011	0.206	0.010	$p = 0.932$
Domestic market share	0.157	0.010	0.145	0.008	$p = 0.358$
Int'l market share	0.156	0.010	0.123	0.008	$p = 0.011$
Keep up with competitors	0.351	0.013	0.315	0.011	$p = 0.040$

Note: All statistics are computed using sampling weights and represent the respective population moments. Industry and province dummies are not presented. The means of those variables differ significantly among groups, too.

Again, we restrict the sample to common support as described above. In this case, we have to exclude 192 treated firms. As this is still a low fraction of the sample (5%), we assume that the matching on the remaining 2,269 control observations leads to consistent results.

The matching results are presented in Table 6. Again, we can conclude that the matching routine balanced the samples sufficiently well: There are no significant differences in covariates (upper panel in the table) and the propensity scores between the treatment group and the selected control group. Hence, we can assign remaining differences in the dependent variables (lower panel) to the receipt of R&D tax credits. The interpretation of results concerning the variables *RDCON*, *NEWPROD*, *NEWSALES*, *WFIRST* and *CAFIRST* do not differ from the previous estimates using the full sample.

Table 6: Mean differences between R&D tax credit recipients and selected control group after the matching (subsample of innovating firms)

Variable	*GVTTAX* = 1 N^1 = 1,384 Mean	Std. Err.	*GVTTAX* = 0 N^0 = 1,384 Mean	Std. Err.	p-value of two-tailed t-test on mean difference
			Covariates		
LNEMP	4.611	0.026	4.646	0.025	p = 0.352
RDDEP	0.468	0.015	0.459	0.015	p = 0.683
RDCONTR	0.279	0.013	0.258	0.013	p = 0.270
NEWNT	0.921	0.008	0.909	0.008	p = 0.277
EXPMT	0.691	0.014	0.675	0.013	p = 0.428
PCM	0.259	0.004	0.262	0.004	p = 0.628
INDRD	1.702	0.058	1.644	0.053	p = 0.460
Propensity Score	0.503	0.006	0.496	0.006	p = 0.455
			Outcome variables		
RDCON	1.000	0	0.731	0.013	p < 0.001
NEWPROD	2.522	0.047	2.291	0.052	p = 0.001
NEWSALES	2.037	0.040	1.737	0.040	p < 0.001
WFIRST	0.173	0.011	0.081	0.008	p < 0.001
CAFIRST	0.412	0.014	0.264	0.013	p <0.001
			General performance variables		
Profitability	0.210	0.012	0.225	0.013	p = 0.417
Domestic market share	0.159	0.011	0.141	0.011	p = 0.238
Int'l market share	0.153	0.011	0.131	0.010	p = 0.138
Keep up with competitors	0.353	0.014	0.317	0.014	p = 0.081

Note: All statistics are computed using sampling weights and represent the respective population moments. Industry and province dummies are not presented. The distribution of observations over industries is identical in the treatment group and the control group and it does not differ significantly among regions.

The more general performance indicators - profitability, domestic and international market share - are not significantly different between the two groups. Only the mean difference in "keeping up with competitors" is weakly significant at the 10% level. These variables report the respondents' assessment of the performance impact of innovations introduced in the course of the previous three years. However, it is possible that the impact of tax credit-supported R&D and innovation activities on firm's performance materializes after a longer than the observed period. Besides, it is also possible that the subjective assessment by respondents may be biased. Thus, before concluding that the tax credit supported R&D and innovation activities do not improve productivity, profitability and other performance indicators, test with longer lags between innovation and objective output measures rather than subjective assessment of the impact indicators should be performed.

5 Conclusions

This paper analyses the impact of R&D tax credits on innovation activities of Canadian firms. Unlike the major part of the literature, this study focuses on innovation output rather than on R&D expenditure. We employ the Canadian 1999 Survey of Innovation conducted by Statistics Canada. The cross-sectional sample used in this study included 4,644 observations. Using a non-parametric matching approach in order to control for a possible selection bias, we find that R&D tax credits have a positive impact on the firm’s decision to conduct R&D. They also increase innovation output of the recipient firms. Tax credit recipients realize a higher number of product innovations, as well as sales of new and improved products. Moreover, as the sales with innovative products increase, it turns out that the innovations are positively evaluated by the market. This is also supported by the tax credit recipients' higher probability of the introduction of real market novelties for both the national Canadian market and the world market. These results hold true for two different estimations. First, we considered the full sample of manufacturing firms, that is, the potential control group for the R&D tax credit recipients is formed from all other firms, i.e. innovating and non-innovating firms. Second, we restricted the analysis to innovating firms only, because some might argue that the results are driven by non-innovating firms in the control group. It turns out that the results are robust against this argument. It should also be noted that the analysis employs sampling weights to all presented statistics. Thus, all findings represent the corresponding population figures rather than sample results.

While we find positive effects on the direct output of R&D activities, i.e. number and sales of new products, there is no effect on more general firm performance indicators that have been surveyed. In particular, responses to the question "What impact did new or significantly improved products (goods or services) and new significantly improved production/manufacturing processes [...] have on your firm?" were evaluated. Dummy variables indicate whether respondents strongly agreed that recent innovations a) increased the profitability of the firm, b) increased the firm's domestic market share, c) increased the firm's international market share, and d) allowed the firm to keep up with its competitors. As we do not find significant differences between the recipient firms and the selected control group representing the recipients in the counterfactual situation of the absence of R&D tax credits, we conclude that recent innovations might affect economic performance indicators such as profitability, productivity, and market shares in the medium or in the long run only, if at all.

For further research it would be interesting to have panel data on R&D tax credits and performance indicators based on objective measures to pursue these questions. However, even panel data is not a panacea. It is likely that time-lags between innovation and its impact on firm performance varies significantly across industries. In this case in-depth industry studies would be required.

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