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The Effects of Public R&D Subsidies on Private R&D Activities in Mexico (Chapter 1)*

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Abstract

This paper analyses the impact of a public research and development (R&D) subsidy to private firms in Mexico. My estimates suggest that the subsidy has a positive impact on personnel allocated to innovation activities, but it does not have an effect on other measures of R&D performance, such as research personnel, patents or private R&D spending. I argue that awarded firms would have performed their planned R&D projects in case they were not granted the public funds. Additional public funds seem to be invested in allocating more personnel on already planned projects, but not on carrying out additional ones. Specifically, I analyze the *Programa de Estímulos a la Innovación* (PEI) subsidy. The program's rules set a grade threshold below which no R&D projects get the grants and above which some projects are granted. This granting process allows to use a fuzzy regression discontinuity approach to identify causal inference.

Keywords: R&D, Innovation, Regression Discontinuity, Public Policy

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1 Introduction

Most governments in high income countries subsidize private research and development (R&D). Previous literature finds that R&D subisidies are beneficial, as in most cases, they crowd in private R&D spending.[1] In the last decades, some middle income countries have put these subsidies in place. However, this policy may not be effective in these economies. We can deduce many facts behind this reasoning. To name a few: 1) when faced with problems that require R&D, firms in middle income countries may choose to adopt solutions already created in countries at the technology frontier, instead of investing in their own R&D; or 2) highly qualified personnel or research equipment is relatively scarce in these countries. Since few middle income countries grant R&D subsidies to private firms, research about the success of the policy in their economic context is limited. I know of just one study –by Özçelik and Taymaz (2008) in Turkey– that studies the impacts of R&D subsidies in a middle income country. They find positive effects, but mostly for small sized firms. My paper contributes firstly to fill this gap in the literature, as I study the impacts of a public R&D subsidy on private R&D activities in Mexico, a country far from the technology frontier.

My estimates suggest that the subsidy leads firms to allocate more personnel to innovation activities. However, I do not find evidence of impacts on the other outcomes I analyse: research personnel, patenting activities and private R&D spending. In this paper, innovation is defined as the creation of new products that may come from well defined projects or from *non-systematic* work, such as spontaneous ideas. While research is defined as *systematic* work that increases knowledge and results in the creation of new products. Innovation is the weakest of the R&D outcomes I review, as it does not require carrying out systematic R&D work. I argue that, on average, granted firms would have taken on their planned R&D projects even in the absence of the public grants. In case firms receive the subsidy, the additional public resources seem to be invested in allocating more personnel to the planned

[1] The paper by Becker (2015) reviews extensively previous literature on the effects of R&D subsidies.

R&D projects, but not on carrying out additional ones. Previous literature mostly focuses on the subsidy effects on private R&D spending.[2] So, a second contribution of my research is studying various outcomes. This gives a more integral picture of the policy effects.

Specifically, in this paper I study the effect of *Programa de Estímulos a la Innovación* (PEI), a R&D subsidy granted by Mexico's *Consejo Nacional de Ciencia y Tecnología* (CONACYT). Until year 2018, PEI was CONACYT's largest R&D subsidy to private fims. Then, the federal goverment that took office on December 1, 2018 decided to cancel further grants from the program. Companies that applied to the PEI subsidy had to submit at least one R&D project following guidelines clearly defined by CONACYT. The program's rules specified that submitted projects were graded on a 0 to 110 point scale by three different evaluators mostly independent from CONACYT. None of the projects graded below 75 points were granted the subsidy. Projects graded with 75 points or more were passed to a CONACYT evaluation committee. Among these projects, the committee chose the ones to award based on the evaluators assessments. This granting process allows to use the regression discontinuity design (RDD). The RDD method is based on the assumption that firms just below and just above the threshold are similar and only differ by the fact that those above the threshold receive the subsidy. This quasi experimental setting deals with the problem of sample election bias and allows to get casual inference from the estimates. Since not all firms above the threshold are granted, I follow the *fuzzy* RDD method, which consists of two stage least squares (2SLS) regressions. In the first stage, I regress subsidy reception on the grade. And in the second stage, I regress the outcomes on the first stage predicted subsidy reception.[3] Previous research on the effects of R&D subsidies on private R&D, mostly relies on estimation techniques that select on observables to deal with the

[2]Papers by Czarnitzki and Licht (2006), Hussinger (2008) and Bronzini and Iachini (2014) analyze more outcomes additional to private R&D spending but their results are not uniformly conclusive.

[3]Bronzini and Iachini (2014) use a similar approach for Italian R&D subisides. However, they apply *sharp* RDD to their estimates, as all firms above the Italian threshold are granted with the subsidy. A detailed description of regression discontinuity estimation can be found in work by Jacob et al. (2012) and Cattaneo et al. (2019).

selection bias problem. So, the third way this paper contributes to previous literature, is by using a quasi experimental setting to obtain the estimates. This allows to infer causality more transparently.[4]

This paper relies on two sets of data. The first is administrative data on the PEI subsidy. This dataset is not publicly available. It was provided by CONACYT personnel. It contains information on 6,369 R&D projects submitted to the PEI program by 2,845 firms from 2011 to 2013. The second source of data is the 2014 Economic Census collected by *Instituto Nacional de Estadística y Geografía* (INEGI). The census datasets provide information on the research outcomes I analyze.

The remainder of the paper is structured as follows. In Section 2, I present a summary of previous research on the impacts of public R&D subsidies. Then, Section 3 gives a general description of the R&D context in Mexico and presents the PEI subsidy in detail. Section 4 describes the data I use in this research and explains the methodology. Section 5 shows tests that support the methodology and presents the results. Finally, Section 6 concludes.

2 Literature Review

Research and development (R&D) activities are credited for having positive spillover effects on the economy, particulaly on productivity.[5] However, as Becker (2015) points out, private R&D spending exhibits a classic public goods problem: private firms do not appropriate completely the returns of their own R&D investment as some of the benefits are absorbed by other economic agents.[6] The presence of both positive impacts of R&D and private re-

[4] I know of just two other studies that use a quasi experimental setting to analyse the impacts of R&D subisidies. The studies are those of Lach (2002) in Israel, and Bronzini and Iachini (2014) in Italy.

[5] See the firm level research by O'Mahony and Vecchi (2009) in the US, UK, Japan, Germany and France; the industry level study by Cameron et al. (2005) in the United Kingdom; and the country level study by Bravo-Ortega and García Marín (2011).

[6] Evidence of this problem is provided by Griliches (1979).

turns being lower than the social optimum, provide the the classical argument in favour of public support of R&D activities: if governments subsidize private R&D, total R&D investment may move closer to the social optimum. A different argument in favor of government support of private R&D concerns the risky nature of these activities.[7] This riskiness leads to relatively high financial constraints, as private borrowers are less prone to finance R&D activities. So, public funding of R&D might encourage private firms to invest more heavily in these activities by decreasing financial constraints.

The arugments in favour of public R&D support may be solid. Yet, the earliest studies on the effect of public R&D subsidies on private R&D got ambivalent conclusions on its effectiveness. David et al. (2000) present an overview of literature on the subject from the 1960s to the 1990s. About half of the 19 firm level studies they review report that direct R&D subsidies have crowding-out effects on private R&D spending, i.e. firms decrease their private R&D expenditure when they receive the subsidies. This early work bears some shortcomings. First, it relies heavily on US data –about half the studies concern the US–, so it ignores the particular contexts that may arise in other countries. In addition, early studies neglect the problem of sample selection bias, as most of them use ordinary least squares (OLS) estimation in the absence of an experimental or quasi experimental setting. So, these studies do not confront the typical endogeneity problem of impact evaluation research. Among other concerns, R&D intensive firms may be more likely to apply for –and be granted with– R&D subsidies. In this context, OLS estimates might be biased.

Recent literature employs other econometric techniques, such as matching or instrumental variables, to address the sample selection bias problem. This literature gets estimations that point to complementarity effects of public R&D subsidies on private R&D activities, putting the policy in a more favorable light. Almus and Czarnitzki (2003) and Czarnitzki

[7] Research by Hyytinen and Toivanen (2005) and Czarnitzki (2006) indicates that investment in R&D activities is riskier than investment in physical assets.

and Licht (2006) examine these subsidies in Germany and find that public R&D support leads to an increase in private firm R&D activities.[8] A different study by Carboni (2011) focuses on manufacturing Italian firms in the 2001-2003 time span. The author finds that R&D subsidies to private firms increase private R&D spending. In addition, subsidized firms tend to take on more credit to invest in R&D. The author interpets this as evidence that public funding alleviates credit constraints faced by the risky nature of R&D spending. In a different study, Aerts and Schmidt (2008) study public R&D subsidies in Flanders and Germany in the 2002-2004 period. They find that subsidies increase private R&D expenditure. The authors argue that finding similar results in two different countries gives robustness to their findings.[9]

Additional research finds positive effects of direct subsidies on private R&D activities for subsets of receiving firms. Lach (2002) examines direct R&D subsidies in Israel and finds no statistically significant effect on all receiving firms. However, small subsidy receiving firms significantly increase their private R&D investments. The author suggests that large subsidized firms would have performed the R&D projects in the absence of public support. Whereas, public funding for small firms is escencial for them to take on R&D activities. A similar conclusion is reached by Bronzini and Iachini (2014). They investigate R&D subsidies in Italy a find that small subsidy receiving companies increase their own R&D expenditure by approximately the same amount of the subsidy. They find no effect for the whole sample of subsidy receiving firms. In Turkey, Özçelik and Taymaz (2008) find that R&D subsidies have a larger effect on small firms. Becker and Hall (2013) analyze these subsidies in the United Kingdom. They find that granted firms in low technology sectors increase private R&D expenditures, while firms in high technology sectors do not.

[8]The authors suggest that firms in Estearn Germany are more responisive to public funding because other sources of R&D funding are scarce compared to the west. However, Western German firms are more succesfull when it comes to patenting results. This may be due to the largest expertise of firms in the west in carrying-out R&D activities: they can translate funding more effectively into patents.

[9]Other studies that find crowding-in effects of R&D subsidies on private R&D spending are those of Bloch and Graversen (2012) in Denmark and Hussinger (2008) in Germany.

Finally, there is a set of research on R&D subsidies that does not find complementarity effects on private R&D activities, but it does not find crowding out either. Duguet (2004) analyzes public R&D subsidies to private firms in France and concludes that they have no effect on the growth rate of firm's R&D spending to sales ratio. González et al. (2005) and González and Pazó (2008) analyze R&D subsidies in Spain. They both find that subsidies have no impact on private R&D spending, i.e. firms would continue to perform the same R&D projects in the absence of public funds. Cerulli and Poti (2012) estimate the impact of R&D subisidies on Italian firms. They do not find either crowding out or crowding in effects in various subsets of awarded firms.

Therefore, recent research mostly finds that public R&D subsidies lead private firms increase their R&D activities. A few find no effect on private R&D. But evidence of displacement of private R&D due to the subsidies is scarce in the latest studies. Still, an important caveat remains: this line of research remains almost exclusively performed in high income countries. Apart from that, even the latest studies present a methodological problem: they rely heavily on estimation methods that select on observables. Studies that examine an experimental or quasi experimental setting are scarce.

3 R&D Spending in Mexico

R&D activities are commonly defined as the work that leads to increasing knowledge, and using such knowledge to create new products, services or applications (OECD, 2015). In Mexico, the largest source of R&D public funding is *Consejo Nacional de Ciencia y Tecnología* (CONACYT), the agency in charge of most federal government public policies on research, science and technology. In 2017, it spent 46 percent of all federal government's R&D expenditure, vastly outpacing federal public universities, the second largest contributors, at 28 percent of the total. This makes CONACYT the biggest contributor to R&D spending, not only in the federal government, but the whole country.[10] In year 2015, CONACYT's main disbursements went to: 1) its own research centers, which in 2015 got close to 30 percent of the agency's budget, 2) scholarships for graduate students with around 20 percent, 3) a program targeted to increase Mexico's researchers productivity with nearly 10 percent, and 4) subsidies to private firm's R&D projects with close to 15 percent of the budget (CONACYT, 2017).

Total (public and private) R&D spending in Mexico amounted to 0.48 percent of GDP in year 2017. This rate remained somewhat stable in the decade, ranging from 0.43 to 0.54 percent of GDP. Most of the country's R&D spending is financed by the public sector –around 60 to 70 percent of the total depending on the year–. Private for profit firms contribute with around 20 percent, while universities and non for profit organizations spend the rest (CONACYT, 2017). Mexico's expenditure on R&D is slightly below the Latin American mean of 0.55 percent of GDP. However, it is considerably lower than Brazil's, the region leader, at 1.28 percent of GDP (in 2014). Moreover, compared to high income countries, Mexico's R&D spending is quite low: the average for OECD countries stands at 2.35 percent of GDP. South Korea and Japan show the largest shares at 4.24 and 3.14 percent respectively, far from Mexico's 0.48 percent (OECD, 2018). For most OECD countries, R&D spending mostly comes from the private sector, as opposed to many Latin American countries, where the largest share comes from public sources. So, in order to significantly increase Mexico's total R&D spending, it seems likely that not only public sources should rise, but also private ones, as is the case in countries with higher R&D/GDP shares. This research is relevant, as it may shed light on the country's R&D subsidies effectiveness for this aim.

[10] In 2017, Mexico's federal government alloted 61,154 million MXN (3,235 million USD) to R&D spdending. CONACYT spent 28,181 million MXN (1,486 million USD) on R&D, amounting to 0.13 percent of the country's GDP. For more information, see CONACYT (2017).

3.1 The PEI Subsidy

CONACYT's largest fund granting R&D subsidies to private firms is *Programa de Estímulos a la Innovación* (PEI).[11] In 2015, it awarded 4,054 million MXN (255 million USD) to 821 projects. In 2009, the year it was created, PEI granted 2,365 million MXN (175 million USD) to 503 projects.[12] This amounts to a 71 percent growth in money granted in that time span. The government that took office in December 1, 2018 decided to cancel new allocations to PEI and greatly diminished transfers to other funds that granted subsidies to private firms. The new administration argues that, instead of transferring R&D subsidies to large private firms, funds may have more beneficial impacts if they are transferred to other entities such as public research institutions or universities.[13]

Companies that wished to apply to PEI's grants had to be legally constituted, registered with the tax authority and up-to-date with their tax obligations (i.e. informal firms were not eligible). To receive the grant, companies had to submit a R&D project to CONACYT defining clearly the activities to be undertaken with the subsidy. PEI grants could only be spent in the submitted project.[14] A company could submit more than one project to the grants in the same year. Moreover, more than one project per company could be financed in the same year. However, projects already financed by a different CONACYT program –including those of CONACYT partnerships– could not be submitted to PEI. This effectively ruled out most of the other available public R&D funds in Mexico. To qualify for the subsidy, companies had to finance a part of the R&D project with their own resources.[15]

[11] Apart from the PEI program, CONACYT granted R&D subsidies to private firms mainly with two other programs: 1) the "mixed founds", which were operated by CONACYT and its local counterparts in the country's States (and a few cities); and 2) the "sectoral funds", which were managed jointly by CONACYT and a federal ministry.

[12] MXN amounts are presented at constant 2018 prices.

[13] See the press conference on June 27, 2019 by CONACYT director María Elena Álvarez-Bullya https://www.youtube.com/watch?v=i5cYvoXEzGM.

[14] Firms could choose to partner their R&D project with a research center or university. The PEI grant could finance expenditures performed on the project by the research partner and by the company itself. The grant had to be spent on the calendar year it was awarded.

[15] The minimum share that companies had to finance varied depending on the size of the firm and whether

All projects submitted to the PEI grants were graded by three different evaluators chosen from a directory of CONACYT official evaluators. Evaluators were usually academics, scientists or researchers affiliated to universities or research centers. They were typically not directly hired by CONACYT but could collaborate with the agency on other projects. The evaluation was performed according to a guide provided by CONACYT. The grade could go from 0 to 110 points. The minimum grade required for the project to be considered candidate for a grant was 75 over 110 points. All projects marked 75 points and above were sent to a CONACYT evaluation committee. This committee chose the projects to be awarded based on the assessments made by the evaluators and the information contained in the submitted documents describing the project. Not all projects graded above 75/110 got the grant. The committee could have used criteria other than the project grade –as long as it was above the 75 point threshold– to decide which projects to award. However, as shown in Section 5, the grade was a good predictor of the granting decision, which is essential for my estimation strategy. Each project final grade was the mean grade given by the three different evaluators. Both submitting firms and evaluators were aware of the 75/110 grade threshold as rules are clearly described in publicly available documents describing the program.[16] I discuss concerns that this might bring to my estimation strategy in Section 4.2.

4 Data and Methodology

4.1 Data

This research relies mainly on two sets of data. The first one is an administrative dataset provided by *Consejo Nacional de Ciencia y Tecnología* (CONACYT). It contains informa-

the project was linked with a research institution or not. It could go from 35 to 75 percent of the project's total value. In addition, there was a maximum limit on the amount to be granted by the PEI subsidy. The maximum amount varied according to company size and cosponsoring with a research center. In year 2013, this maximum amount went from 21 million MXN (1.6 million USD) to 36 million MXN (2.81 million USD).

[16]Detailed information on the PEI progam can be found in CONACYT (2013).

tion on 6,369 R&D projects that were submitted to *Programa de Estímulos a la Innovación* (PEI) grants from 2011 to 2013 by 2,845 companies. The dataset provides information on the project's sector, a short description of its objective, the subsidy granting decision (whether it got the PEI subsidy or not), cosponsoring status (with a university o research center), and the grade assigned by the evaluators. The second main dataset I use in this research comes from the 2014 Economic Census collected by *Instituto Nacional de Estadística y Geografía* (INEGI). The census datasets can be accessed by researchers at INEGI's Microdata Laboratory. The census gathers information on companies performing economic activities in Mexico that can be located on a fixed address. This dataset provides the research and development outcomes I analyze.

Data on the PEI dataset is provided yearly. However, the census is gathered every five years. The economic census released on year 2014 contains information that corresponds to activities performed on year 2013. The census prior to that was released on 2009 (with information corresponding to year 2008). Hence, 2013 is the only year in the PEI dataset that I can merge with its corresponding census year. However, I also merge PEI companies that submitted projects in 2011 and 2012 to this census for three reasons: First, PEI subsidies may have a lasting effect on firm outcomes. Second, some questions in the 2013 census are posed for activities performed in 2011 and 2012. Third, including 2011 and 2012 firms increases the number of observations and thus the precision of my estimates.[17]

The PEI and the census datasets do not count with a common code that uniquely iden-

[17]It is of interest to present a brief description of Mexico's economic context on year 2013. GDP growth entered a slight stagnation, but it still grew at a positive rate of 1.1 percent. Growth in years 2011 and 2012 showed a rate of 4.0 and 3.9 respectively. Investment on year 2013 contracted by -1.8 percent, which mostly came from a decrease in public sector investment. However, industrial production grew at a positive rate of 0.7 percent. Employment grew by 2.9 percent compared to the previous year. Average salaries grew as well by 4 percent. The inflation rate showed a moderate growth of 3.9 percent. Thus, even if Mexico's economy showed a slight decrease in the growth rate in 2013 compared to previous years, it was not a particularly atypical year in terms of the evolution of the Mexican economy, as most relevant economic indicators showed positive growth rates. More information on Mexico's economic context on year 2013 can be found in SHCP (2013) and SHCP (2014).

tifies the firms in both datasets. Hence, to merge the firms across the two sets of data, I can only use a few identifying variables present in both: the firm's name, state location and sector. Merging firms this way bears some complications. Among others, spelling mistakes are common in both datasets. I follow a special algorithm to merge the firms.[18] With this algorithm, I successfully merge 1,360 firms. This is only around 50 percent of the total companies that submitted a project to the PEI subsidy in the 2011 to 2013 period. This may be problematic as the merged company sample might be systematically different to the original PEI dataset. This dataset does not contain many statistics to compare the merged versus non merged firms. However, in Table 1 I show some firm characteristics that provide a general view of the type of firms I loose in the merging process. The table shows the number of firms in the PEI dataset by year, as well as the number of firms merged to the 2014 Economic Census. The share of firms receiving the subsidy is regularly around 25 percent of those that submitted projects to PEI. This share remains similar in the sample of firms that I merge to the census. However, regarding company size, I loose relatively more small firms than large firms in the merging process. Small firms in the PEI dataset represent around 70 percent of all submitters, but they compose only around 50 percent of the firms in the merged sample. I argue that this does not pose a problem to my identification strategy as long as the firms in the merged sample remain similar across the 75 point threshold and do not show evidence of bunching across the cut off. Evidence of this is presented in Section 5.

4.2 Methodology

The objective of this research is to find if the *Programa de Estímulos a la Innovación* (PEI) R&D subsidy has an impact on a series of firm outcomes related to R&D activities. Consider the following basic econometric model:

$$Y_i = \alpha + \beta S_i + \epsilon_i \tag{1}$$

[18] A detailed description of the algorithm is provided in Appendix A.

where Y_i is the outcome for firm i, S_i is a variable equal to one if firm i receives the subsidy and zero otherwise, and ϵ_i is a random error. In equation (1), β represents the effect of receiving the PEI subsidy on the outcome. However, as awards are not randomly allocated, if I estimate equation (1) by ordinary least squares (OLS), parameter β is likely to be biased as awarded and non-awarded firms can differ on unobserved characteristics correlated with outcome Y_i. For instance, suppose the outcome in Y_i is patent registrations. If firms that have higher propensity to register patents, also have higher expertise in submitting projects to public R&D funds and are more likely to receive the subsidy, β would be biased upwards. I.e. β's estimated value from equation (1) would be higher than its true value.

To face this problem, I take advantage of the rules that define the PEI granting decision. As described above, all projects submitted to the PEI subsidy are graded on a 0 to 110 scale. Projects with grades of 75/110 points or higher are passed to a CONACYT committee that decides which projects receive the subsidy. Projects with grades lower than 75 points are not passed to the committee and hence do not receive the PEI grant. This granting scheme allows to use a regression discontinuity design (RDD) approach similar to that taken by Bronzini and Iachini (2014) in their study on Italian R&D subsidies. This approach assumes that assignment to treatment is random close to the threshold, so the average treatment effect (ATE) can be assessed with the estimated value of the discontinuity at the threshold.

Bronzini and Iachini (2014) use a *sharp RDD* approach, as in the Italian rules all projects graded above the threshold get the grant, and no project below the threshold is granted, i.e. the granting decision is determined solely by the grade. PEI's granting rules are different: no projects below the grade threshold are awarded, but not all the projects graded 75 or more get the subsidy. The granting decision for projects graded above the threshold is not clearly outlined in the PEI rules. In order to decide which projects get the subsidy, the committee might take into account other considerations in addition to the project grade, such as, company size or reputation, prioritized industrial sectors, CONACYT's own funding availability, among others. Treatment is only partially determined by the project grade at the grade cut off. So, the probability to receive the subsidy does not go from zero to one as the project crosses the 75 grade threshold. To handle this setting, I use the *fuzzy* regression discontinuity framework outlined in Angrist and Lavy (1999), Van Der Klaauw (2003) or Berlinski et al. (2011). The estimation of the treatment effect in fuzzy RDD is done by the two stage least squares (2SLS) method. In the first stage, I estimate a predicted value of subsidy reception $\hat{S}_i$ that depends on the grade. In the second stage, I use $\hat{S}_i$ to estimate the impact of the PEI subsidy on a series of outcomes.[19]

Let me now describe with more precision my estimation approach. As mentioned before, one company could submit more than one project to PEI in the same year. Define $G_{ij} = grade_{ij} - 75$, where $grade_{ij}$ is the grade given to project j submitted by company i. A project j is passed to the committee if $G_{ij} \geq 0$. However, we are interested on outcomes at the company –and not the project– level. To aggregate the grade at the company level, I take the *mean* grade of all projects submitted by company i, and I define G_i as company i's mean grade.[20] In the sharp RDD approach, the ATE is estimated with the discontinuity at

[19]To see a detailed description of the regression discontinuity method, see Jacob et al. (2012) or Cattaneo et al. (2019).

[20]The criteria to aggregate the grade by firm is not straightforward. Instead of the mean, I could take the firm's *maximum* project grade. However, the maximum grade pushes most subsidy receiving firms far from the grade threshold, leaving a small discontinuity jump at the cut off to do the RDD estimations (in Table B1 of Appendix B, I present the estimations I obtain with the maximum grade aggregation criterion). A drawback of taking the mean grade might be that it pushes many subsidy receiving firms below the threshold. This would be problematic in a sharp RDD approach. However, fuzzy RDD assumes that the rating variable (the grade) is not the only one that determines assignment to treatment in either side of the threshold. Thus, having treated firms below the threshold does not invalidate my estimates. Furthermore, my decision to take the fuzzy RDD approach is not the result of the mean grade aggregation criterion. If I had used the maximum grade, I would still have had to use fuzzy RDD, as not all firms above the threshold are treated. So, I prefer to use the mean grade since it provides a higher discontinuity at the threshold that I can use to get more precise estimates. In Figure B2, I present the mean granted subsidy by firm mean grade ranges. The figure shows that the highest grades get higher mean subsidies. However, there are no big jumps in subsidy amounts at the threshold that could drive the results I get in my estimations. An additional approach to do the estimations could be to only use the firms that submitted one project. However, the number of firms that fall into this category is too small to provide significant estimates with fuzzy RDD.

the threshold:

$$Y_i = \alpha + \beta S_i + (1 - S_i)\sum_{p=1}^{P}\gamma(G_i)^p + S_i\sum_{p=1}^{P}\gamma(G_i)^p + \epsilon_i \tag{2}$$

where β gives the value of the discontinuity and a set of P order polynomials are included to account for non linear relations between the grade and the outcome variables. However, as mentioned above, subsidy reception is not entirely determined by the grade. So, as is standard in the fuzzy RDD literature, I follow a 2SLS approach, where I instrument subsidy reception S_i with variable T_i, which is defined as:

$$T_i = \begin{cases} 1, & \text{if } G_i \geq 0 \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

i.e. $T_i = 1$ if the mean of all the projects submitted to PEI by firm i in a given year is higher or equal to 75. In the first stage I estimate the following equation:

$$\hat{S}_i = \kappa + \lambda T_i + (1 - T_i)\sum_{p=1}^{P}\mu(G_i)^p + T_i\sum_{p=1}^{P}\mu(G_i)^p + \nu \tag{4}$$

From equation (4), I get a predicted subsidy reception value $\hat{S}_i$ that depends on the grade and on a set of P order polynomials. In the second stage I use $\hat{S}_i$ to estimate the causal impact of the PEI subsidy in a series of R&D outcomes:

$$Y_i = \alpha + \beta \hat{S}_i + (1 - S_i)\sum_{p=1}^{P}\gamma(G_i)^p + S_i\sum_{p=1}^{P}\gamma(G_i)^p + \epsilon_i \tag{5}$$

I test different P order polynomials in both stages. In addition, I estimate the 2SLS equations using both the parametric and the non parametric approach that is common in the literature. For the parametric approach, which involves trying polynomial functions of different orders to find the best model suited to the data, I use all observations in the sample of merged firms and estimate equations (4) and (5) with up to polynomials of order five.

For the non parametric approach, which involves trying different bandwidths within which the functional form can be approximated with a linear function, I restrict observations to two different sample windows of ±30 and ±15 points around the cut off, and use up to two order polynomials. The wide window includes 85 percent of the baseline sample. The narrow window includes 60 percent of the baseline sample. I do not restrict the sample further by getting closer to the cut off since the power to detect effects in fuzzy RDD designs is considerably lower than that of sharp RDD, let alone a comparable randomized trial.[21]

In addition, for β to identify a casual effect of the PEI subsidy, T_i must not be correlated with the outcome ($cov(T_i, \epsilon_i) = 0$). Correlation could take place if companies had a way to influence the grade around the 75 grade threshold. For instance, firms that carry out more R&D activities might have more experience applying to the PEI funds. If these firms have learned ways to influence the evaluators grading decisions, for instance, by submitting projects in a way they know will be more favourably graded, the grade would be endogenous and my estimation approach would be invalid. This concern is partially solved by the fact that the 75/110 grade rule, the submission guidelines and the grade guidelines, are announced to all applying firms. In addition, the projects are graded by three different evaluators that are not announced to the applying firms, which makes influencing all their decisions harder. In any case, I address these concerns empirically by verifying the smoothness of G_i through visual inspection, and by performing tests to evaluate bunching around the cut off. In addition, I verify if firms below and above the threshold are similar

[21] In RDD estimation, the design effect $\frac{1}{1-R_T^2}$, is the size that a RDD sample must have to get the power of a comparable randomized control trial (RCT). R_T^2 represents how the rating variable, in this case, the grade, is distributed around the cut off. For normal distributions $R_T^2 \approx 0.64$. So, in a sharp RDD, the sample size should be $\frac{1}{1-R_T^2} \approx 2.75$ times larger than a comparable RCT, to get estimates as precise. For fuzzy RDD, the design effect is $\frac{1}{(1-R_T^2)(p_t-p_c)^2}$, where p_t is the *show rate*, i.e. firms above the threshold that get the treatment, and p_c is the *cross-over rate*: firms below the threshold that get the treatment. In this case $p_t \approx 0.70$ and $p_c \approx 0.10$. So the design effect is $\frac{1}{(1-R_T^2)(p_t-p_c)^2} \approx 7.72$. My sample size should be around eight times larger than that of a comparable RCT to get similar precision on the estimates. This fuzzy RDD limitations manifest when I restrict the windows to less than ±15 points around the threshold. In Table B3, I show results of equation (5) with a 10 point window around the threshold. Coefficients with this window are not significant for any outcome.

in characteristics not related to the grading decision. They should differ only on the PEI subsidy reception rates. I present these tests in Section 5.

The PEI subsidy specifically grants money for the following factors associated to the submitted R&D project: wages of people working on the project, designs and prototypes, patents and intellectual property, operation costs of the project, equipment for the research laboratory and laboratory improvements. With these factors in mind, I analyzed the 2014 Economic Census variables and selected the following Y_i outcomes: 1) personnel working on innovation activities, 2) personnel working on research activities, 3) patenting activities and 4) private R&D spending.

5 Results

I start by showing evidence that supports my estimation approach. First, I address concerns about bunching around the 75 point threshold. Presence of bunching could mean that some firms can push evaluators to grade them just above the threshold. These firms could have characteristics that are correlated with the outcomes. Figure 1 shows the density of the firm *normalized* average project grade (zero represents the 75 point threshold). I include all firms that submitted projects to the *Programa de Estímulos a Innovación* (PEI) R&D subsidy from 2011 to 2013 that I could merge to the 2014 Economic Census databases. In the figure, we can observe that the density is higher above the subsidy granting threshold. However, we do not observe high drops just below or above the threshold that could invalidate my estimation strategy.[22] I also test firm balance around the threshold. If assignment to treatment is random close to the threshold, there should be no systematic differences between firms

[22]Visual inspection might not be enough to confirm bunching, so, in addition, I perform a test proposed by Cattaneo et al. (2016). The null hypothesis is that there is no manipulation of the density at the cut off. The associated p value to the test's T statistic is 0.653. This means that I fail to reject the null hypothesis and there is no statistical evidence of manipulation at the cut off. In addition, in Figure B1 I show the grade density of *all* projects submitted to the PEI subsidy. Figure B1 shows a distribution similar to that of the mean project project grade by firm of Figure 1. I.e. the density is higher above the threshold, but we do not observe high drops above or below the cut off.

around the grade cut off. In Table 2, I show means of variables not related to treatment, below and above the grade threshold. The table shows that means are not statistically different below and above the cut off for the two sample windows.[23] Furthermore, to support my identification strategy, I must show that the score variable (G_i) displays a discontinuity at the cut off. That is, if firms with average project grades above the 75 point threshold have higher chances of receiving the PEI subsidy. Figure 2 shows that there is indeed a jump at the 75 point threshold. Since G_i is defined as the firm *mean* grade, subsidy reception below the threshold is positive, even as no projects below the threshold receive the subsidy. Nevertheless, firm average grades above the cut off are clearly associated with higher subsidy reception shares. Hence, the empirical tests provide support for my identification strategy, allowing us to move on to examine the impact of the PEI subsidy on the outcomes.

First, I show the effect of the PEI subsidy on innovation personnel. I measure this outcome with a question in the census that asks companies if they had personnel working on innovation activities on year 2013. Firms can respond either "Yes" (= 1) or "No" (= 0). In the census, innovation is defined as the introduction of new or significantly improved products (goods or services) or processes (including production methods) into the market. Innovation may come from well defined projects, or from routine improvements, spontaneous ideas or other *non systematic* factors. Figure 3 plots the firms that submitted a project to the PEI program from 2011 to 2013 (merged to the Economic Census data) and responded the innovation personnel question. The figure shows a discontinuity above the 75 point threshold. So, visual inspection suggests that the PEI subsidy leads firms to increase the probability of having innovation personnel.[24] However, to confirm the statistical significance

[23]In addition, in Figure B3, I show bin averages by grade for these non related to treatment outcomes (normalized by production value). The figure provides visual inspection of jumps at the cut off. We can rule out such jumps.

[24]Observations below the cut off consist of firms that receive treatment as well as others that do not receive it. The same is true for observations above the cut off. Comparing these units has a limited causal interpretation. Jacob et al. (2012) indicate that in fuzzy RDD designs "the treatment effect can be recovered by dividing the jump in the outcome-rating relationship by the jump in the relationship between treatment status and rating" (p. 66). This is the local average treatment effect (LATE), i.e. the impact of the PEI

of this visual inspection, we must examine the estimates of coefficient β from equation (5). A positive and significant value of β would mean that the subsidy increases the probability that firms allocate personnel to innovation activities.

In Table 3, I show the β estimates under different P order polynomials and windows around the cut off. Note that, most estimates for β are positive (only one is negative). Also, several estimates are statistically significant by at least a 99 percent confidence level and the coefficient's magnitudes are not small. Regressions for the complete sample of firms, show statistically significant estimates for the all polynomial orders. However, as I restrict the sample to firms closer to the cut off, estimates of β are significant for the two order polynomial, but not for the one order. Authors such as Gelman and Imbens (2019) give reasons why researchers should prefer lower order polynomials in RDD analysis. One of them being that higher order polynomials give large weights to observations that are far from the threshold. In Figure 3, we see bins that take large values at lower grades. This is due to the fewer observations I have at these scores (see Figure 1). Higher order polynomials give large weights to these observations. So, my preferred β estimates are those of lower order polynomials. As, I get significant results for the two order polynomial, but not for the one order, I cannot conclusively state that the PEI subsidy does lead firms to perform more innovation activities. Still, visual inspection of Figure 3 and estimates on Table 3 suggest that this could well be the case. This would mean that the PEI subsidy increases the probability of allocating personnel to innovation activities by a considerable magnitude, of around 0.4

program on the group of firms that are above the cut off and actually received the subsidy compared to those below the cut off that did not receive it. The outcome rating jump can be recovered from Figure 3 at about 0.1. The treatment status rating jump is seen in Figure 2 at about 0.26. So, apparently, the PEI subsidy leads to an increase of around 0.38 points in the innovation personnel outcome (on a scale from zero to one).

points in a 0 to 1 scale.[25,26]

I am also interested in finding out if the PEI subsidy has an impact on research activities. These are defined in the census as the *systematic* theoretical and experimental work leading to the increase of knowledge, resulting in the creation of new or significantly improved products or processes. I show results for the research personnel outcome in Figure 4 and Table 4. Figure 4 shows a discontinuity for this outcome as well. However, bins have a less clear pattern than for the innovation result. This lack of clarity is confirmed in the regression estimates of Table 4. There, we see that most estimates are not statistically significant for at least a 95 percent level. In the full sample, only one of the polynomial orders is significant above that level. In both the wide and narrow sample windows, I get significant estimates for the two order polynomial, but the polynomial of order one remains not precise. Hence, estimates do not seem to support that the PEI subsidy had an effect on personnel allocated to research. Note that research, as defined in the census, demands more commitment to R&D activities than innovation. Research implies always *systematic* work, whereas innovation may come from routine work, spontaneous ideas or other non systematic R&D activities. In addition, the census research definition has the "work that increases knowledge" component, whereas innovation is just concerned with work aimed at introducing products or processes in the market. This suggests that the PEI subsidy may lead to higher probabilities of hiring R&D personnel. But this personnel is not necessarily invested in lasting research production.

[25] Concerning what type of firms are behind this positive impact on innovation personnel. Figure B5 suggests that it is larger firms which are impacted the most. The figure shows that there is a discrete jump at the threshold for large firms. It shows as well that there is no clear discontinuity when we focus on small firms. However, the coefficient estimates in Table B4 do not confirm this visual observation as they are mostly statistically insignificant for large and for small firms. This lack of significance might be due to the small sample of firms I get when I divide them by size. The sample is specially tiny for small firms, as they do not respond often to the R&D questionnaire in the census. In Figure B4, I present the average subsidy reception by grade and by company size. This figure shows that both large and small firms have a clear discontinuity at the threshold. So, the lack of statistically significant β coefficients by firm size is not due to the treatment uptake.

[26] Sharp RDD estimates from equation (2) are presented in Table B2. The table shows that all estimates are positive and statistically significant. However, they are prone to the endogeneity problems of using sharp RDD in a context where the probability of treatment does not go from zero to one at the threshold.

I also examine if the PEI subsidy has an effect on patents. Figure 5 plots firm patenting activities (measured as registration or acquisition of patents) by firm mean grade. The discontinuity for this outcome is even less clear than the one for research personnel. Furthermore, estimates in Table 5 show that the regression results for this outcome are not precise. In the wide sample window, I get a positive and significant estimate for the two order polynomial but not for the one order. In the narrow window, I do not get statistically significant coefficients for any polynomial. Thus, the subsidy does not appear to have an impact on patents. More personnel dedicated to innovation combined with no changes in patenting, could signal fruitless increased innovation efforts in terms of new patented products or processes. However, the lack of significant effects on the patents outcome may be due to the time span that I analyze. It is plausible that the actual registration of a patent may usually take longer than three years since the start of a R&D project.

Finally, I analyse if the PEI grants led companies to increase their private R&D spending. The aim is to inspect if granted firms (compared to non granted) invest on R&D more of their own money, in addition to the PEI grants they receive. Figure 6 plots average private R&D expenditures (normalized by production value) by average firm grade. A discontinuity in this graph would indicate that firms awarded with the PEI subsidy increase their own investment on R&D in addition to the subsidies received. Figure 6 however, shows no such discontinuity. Regressions in Table 6 confirm that there is no statistically significant effect on this outcome. My inability to detect a statistically significant effect on private R&D expenditures may come from the few observations I have on this variable. Nevertheless, the evidence leads to arguing that extra innovation personnel induced by the PEI subsidy is not financed with additional firm own resources, but with the PEI grants themselves. The lack of effect of the PEI subsidy on private R&D spending means that, on average, granted firms would continue to carry out their planned private R&D spending if they had not received the grant.

To sum up, of the outcomes I analyse, the sole where my estimates suggest a positive impact from the subsidy is innovation personnel. My estimates imply that there is no impact on research personnel, patenting activities or private R&D spending. So, if firms are awarded with the grants, they seem to use the extra funds to allocate more personnel to existing projects, rather than to get new ones started. This process does not seem to result on increased patenting. One explanation for my findings is that my estimates rely relatively more on the larger firms that applied to the PEI subsidies.[27] Probably, large firms see the PEI grants as a cheaper source for financing their R&D projects than the capital market. However, in case of missing public support, they still carry out their planned R&D projects. Previous literature shows evidence in this direction. The papers by Lach (2002), González et al. (2005), Özçelik and Taymaz (2008) and Bronzini and Iachini (2014) in Israel, Spain, Turkey and Italy, respectively, find that small firms tend to be more positively impacted by public R&D subsidies. A different explanation for the lack of significant effects in most outcomes I analyze, may be that private firms in Mexico do not translate efficiently more R&D resources into increased R&D activity. As previously mentioned, firms in middle income countries may have relatively limited access to R&D inputs –like research and laboratory equipment–, than their counterparts in high income countries.

6 Conclusion

The estimates obtained in this research suggest that the PEI subsidy did not have statistically significant positive effects on most outcomes. The subsidy seems to positively impact innovation personnel, but not stronger measures of R&D activities, such as research personnel, patenting or private R&D expenditures. My findings differ from those of numerous studies on R&D subsidies to private firms in high income countries. Those studies find strong

[27] As mentioned in Section 4.1, I could not merge to the Economic Census many of the small firms that applied to the PEI subsidy. In addition, many of those small firms that I could merge do not answer the census R&D questionnaire.

positive effects of public grants on private R&D. More research in middle and low income countries is needed to understand structural reasons that explain my findings. Concerning Mexico's federal government decision to cancel the PEI subsidy. First, I find no complementary or crowding out effects on private R&D spending, so I do not expect private R&D spending to decrease as consequence of the PEI program elimination. However, total R&D expenditure will decease if the funds previously assigned to PEI are not used for R&D activities in different entities. Moreover, since my estimates do not suggest that the PEI subsidy had an impact in the most meaningful measures of R&D, arguably public R&D funds could be invested in entities –research centers, universities, among others– that may be more positively impacted by R&D grants. However, this research cannot assert if, indeed, any of those entities will be more o less positively impacted by public R&D funds than private firms.

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Tables

Table 1: Descriptive statistics of firms in the database

All Firms that Submitted a Project to the PEI Subsidy from 2011 to 2013					
Year	**Total**	**Recevied Grant**		**Company size**	
		No	**Yes**	**Small**	**Large**
2011	1426	1040	386	856	570
		72.9%	27.1%	60.0%	40.0%
2012	713	548	165	504	209
		76.9%	23.1%	70.7%	29.3%
2013	706	510	196	550	156
		72.2%	27.8%	77.9%	22.1%
Total	2845	2098	747	1910	935
		73.7%	26.3%	67.1%	32.9%
Firms that were Merged to the 2014 Economic Census					
Year	**Total**	**Received grant**		**Company size**	
		No	**Yes**	**Small**	**Large**
2011	802	571	231	349	453
		71.2%	28.8%	43.5%	56.5%
2012	304	229	75	149	155
		75.3%	24.7%	49.0%	51.0%
2013	255	184	71	146	109
		72.2%	27.8%	57.3%	42.7%
Total	1361	984	377	644	717
		72.3%	27.7%	47.3%	52.7%

Note: This table shows descriptive statistics on the firms that submitted a project to the PEI subsidy in the 2011 to 2013 period.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table 2: Means of variables unrelated to treatment

		± 30 points		± 15 points	
		Below cut-off	**Above cut-off**	**Below cut-off**	**Above cut-off**
Production value	**Mean**	686,007	780,469	667,241	700,277
	SD	1,122,798	1,179,680	1,179,321	1,107,698
Total assets	**Mean**	112,372	118,139	116,626	107,555
	SD	224,529	245,595	238,524	225,067
Real state assets	**Mean**	65,479	75,892	68,683	66,846
	SD	117,300	139,320	129,396	127,671
Sales	**Mean**	411,492	457,749	354,319	431,711
	SD	794,169	820,072	700,682	778,156
Total expenditures	**Mean**	273,984	324,678	238,010	303,908
	SD	572,730	635,200	485,586	598,324
Financial expenditures	**Mean**	11,920	13,333	11,594	13,126
	SD	24,784	27,633	25,600	27,917
Paid taxes	**Mean**	11,213	10,769	8,542	12,208
	SD	22,780	24,230	18,157	26,308
Paid Soc. Sec. Contributions	**Mean**	6,002	5,816	6,325	5,839
	SD	11,663	10,229	12,420	10,187

Note: This table shows means of variables unrelated to treatment for firms below and above the 75 point threshold.

*** Statistically significant difference at the 1 percent confidence level.

** Statistically significant difference at the 5 percent confidence level.

* Statistically significant difference at the 10 percent confidence level.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table 3: Effect of the PEI subsidy on innovation personnel

Outcome: Was there personnel working on innovation activities in 2013? (Yes=1, No=0)			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	0.193***	0.112	-0.017
	(0.072)	(0.139)	(0.275)
	0.051 - 0.334	-0.160 - 0.385	-0.556 - 0.522
Two	0.400***	0.428***	0.659***
	(0.129)	(0.161)	(0.225)
	0.147 - 0.653	0.113 - 0.743	0.218 - 1.100
Three	0.536***		
	(0.145)		
	0.252 - 0.819		
Four	0.475***		
	(0.175)		
	0.132 - 0.817		
Five	0.525***		
	(0.189)		
	0.154 - 0.897		
Observations	1,207	1,070	761

Note: This table shows β estimates from equation (5). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table 4: Effect of the PEI subsidy on research personnel

Outcome: Was there personnel working on research activities in 2013? (Yes=1, No=0)			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	0.181*	-0.007	-0.073
	(0.101)	(0.205)	(0.418)
	-0.018 - 0.379	-0.410 - 0.396	-0.893 - 0.748
Two	0.331*	0.479**	0.817**
	(0.179)	(0.225)	(0.321)
	-0.021 - 0.682	0.038 - 0.921	0.186 - 1.447
Three	0.675***		
	(0.197)		
	0.288 - 1.063		
Four	0.434*		
	(0.234)		
	-0.026 - 0.894		
Five	0.386		
	(0.295)		
	-0.192 - 0.964		
Observations	1,207	1,070	761

Note: This table shows β estimates from equation (5). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table 5: Effect of the PEI subsidy on patenting activities

Outcome: Did the firm register or acquire patents in 2013? (Yes=1, No=0)			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	0.099	0.182	-0.018
	(0.086)	(0.181)	(0.345)
	-0.070 - 0.268	-0.174 - 0.538	-0.695 - 0.659
Two	0.158	0.523**	0.291
	(0.155)	(0.205)	(0.275)
	-0.146 - 0.462	0.121 - 0.925	-0.249 - 0.830
Three	0.341**		
	(0.171)		
	0.007 - 0.676		
Four	0.421**		
	(0.200)		
	0.028 - 0.815		
Five	-0.000		
	(0.256)		
	-0.502 - 0.502		
Observations	1,207	1,070	761

Note: This table shows β estimates from equation (5). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

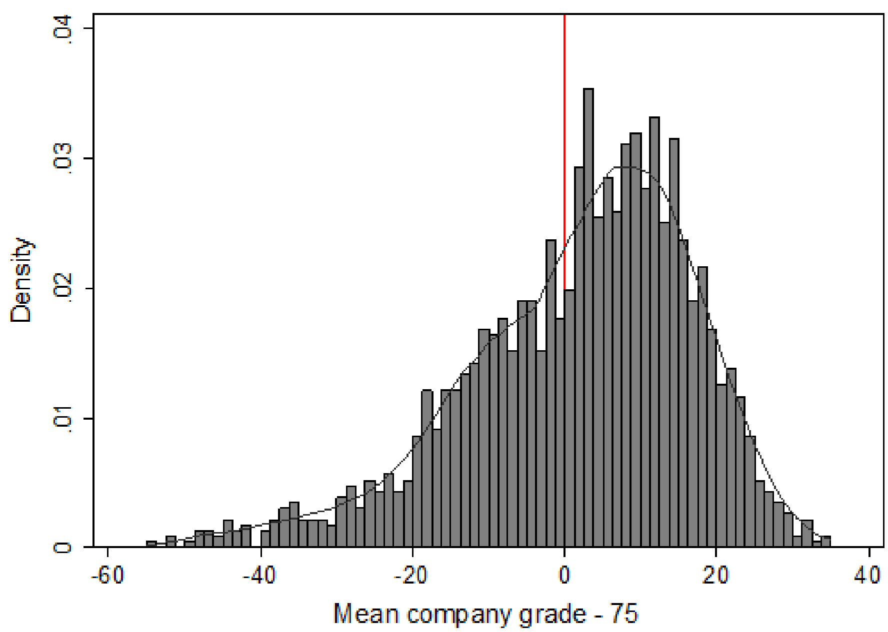
Table 6: Effect of the PEI subsidy on private R&D spending

Outcome: R&D spending / Production value			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	-0.003	-0.007	0.012
	(0.005)	(0.010)	(0.023)
	-0.014 - 0.008	-0.026 - 0.013	-0.032 - 0.057
Two	0.008	-0.005	0.029*
	(0.010)	(0.012)	(0.015)
	-0.012 - 0.027	-0.028 - 0.018	-0.000 - 0.058
Three	0.015		
	(0.011)		
	-0.007 - 0.037		
Four	-0.003		
	(0.012)		
	-0.027 - 0.021		
Five	0.014		
	(0.017)		
	-0.020 - 0.047		
Observations	312	278	199

Note: This table shows β estimates from equation (5). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Figures

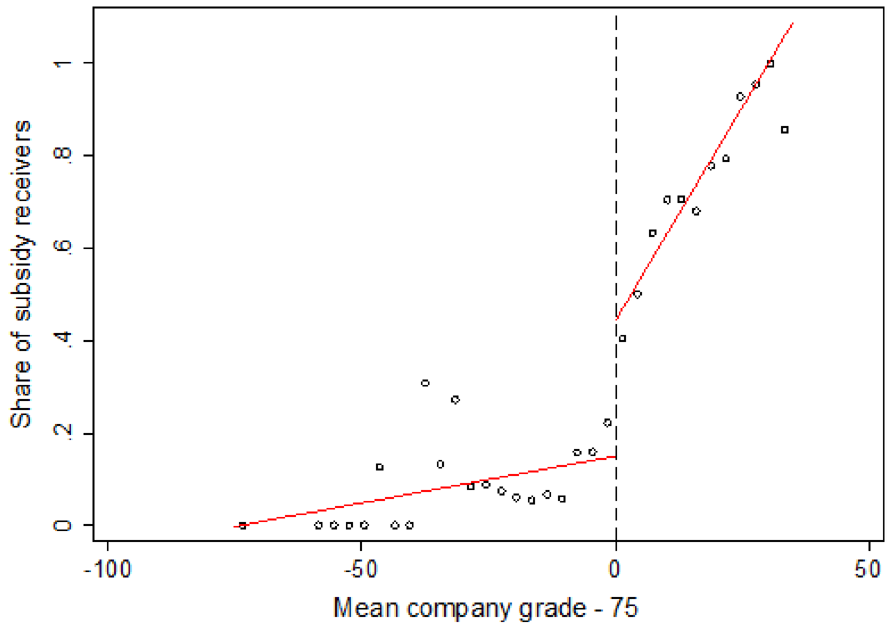
Figure 1: Distribution of firm average grades



Note: This figure shows the density distribution of the firm average project grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census databases.

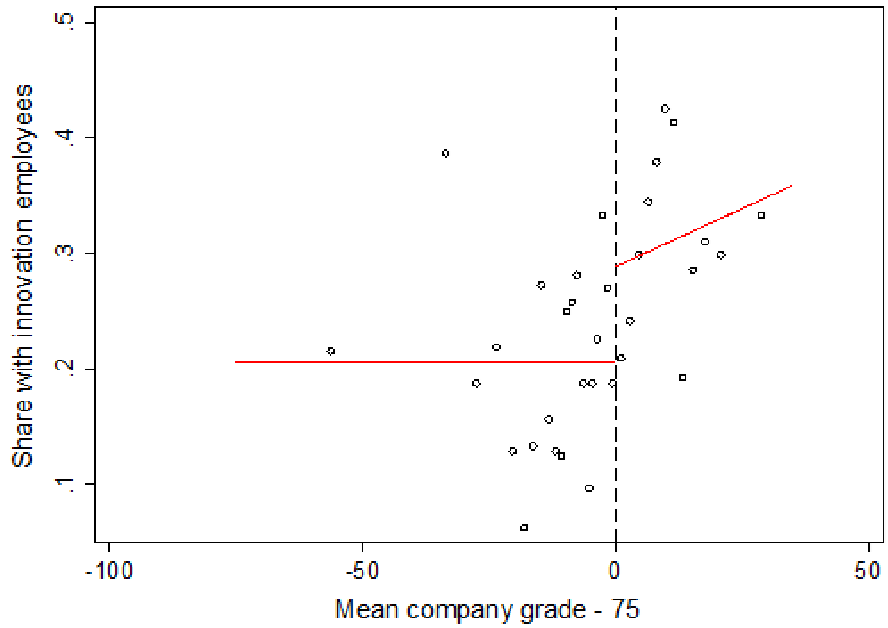
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

Figure 2: Share of firms that received the PEI subsidy



Note: This figure plots average subsidy reception by firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

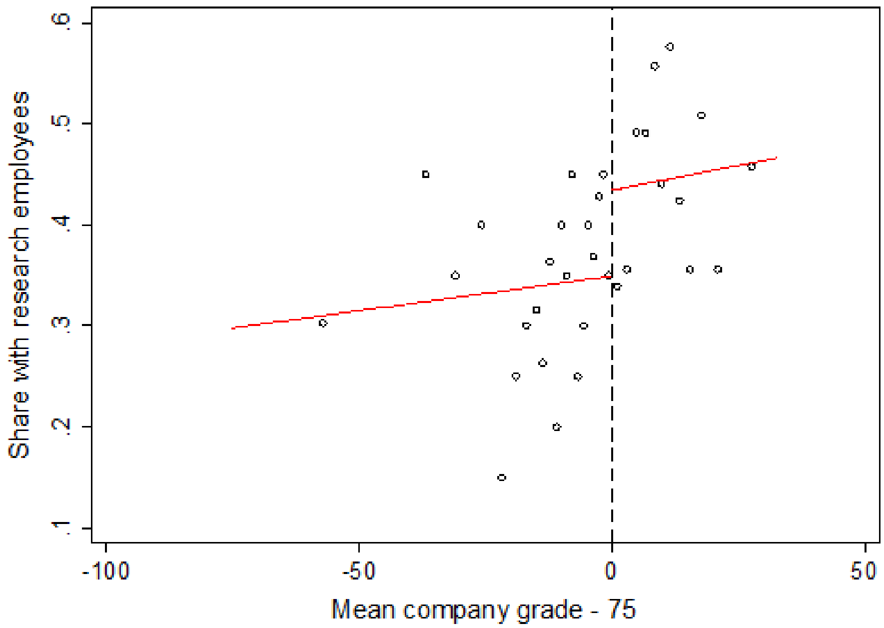
Figure 3: Share of firms with innovation personnel



Note: This figure plots the average share of firms with personnel dedicated to innovation activities by firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

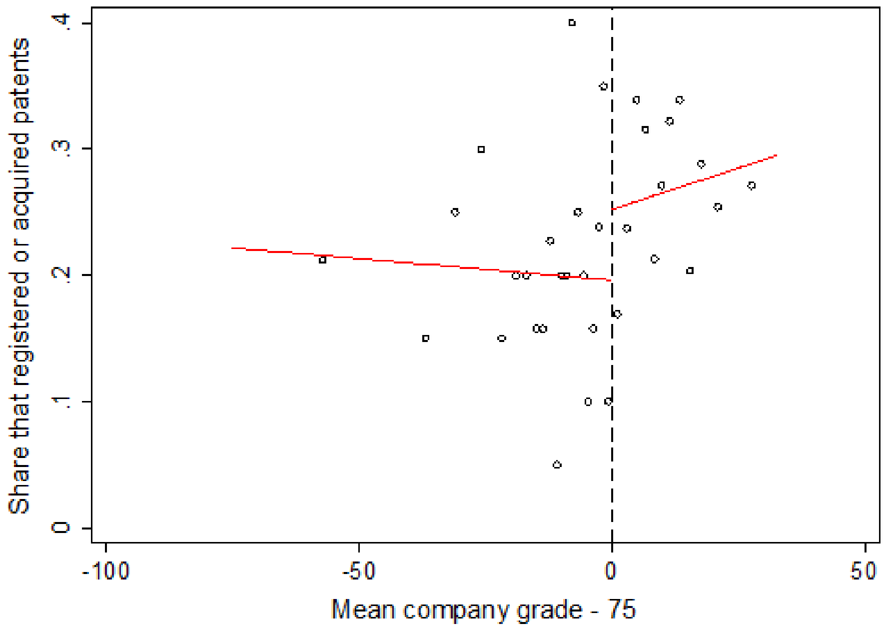
Figure 4: Share of firms with research personnel



Note: This figure plots the average share of firms with personnel dedicated to research activities by firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

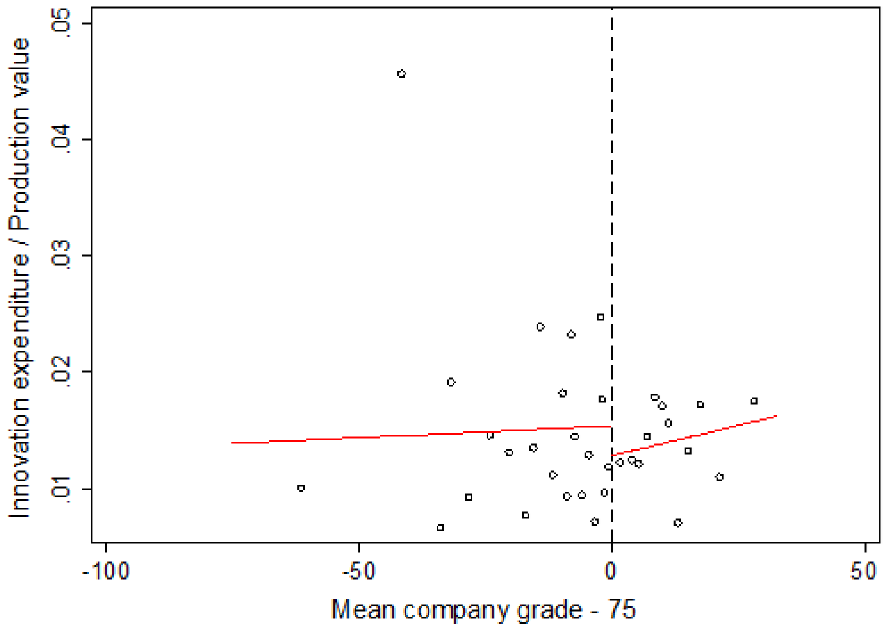
Figure 5: Share of firms performing patenting activities



Note: This figure plots the average share of firms that performed patenting activities by firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

Figure 6: Private R&D spending



Note: This figure plots average private expenditure in R&D activities (normalized by production value) by firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

A Merging Datasets

I merge two sets of data. The first set is provided by *Consejo Nacional de Ciencia y Tecnología* (CONACYT) and includes all firms that submitted a project to the *Programa de Estímulos a la Innovación* (PEI) subsidy from 2011 to 2013. The second set is the 2014 Economic Census collected by *Instituto Nacional de Geografía y Estadística* (INEGI). To identify firms across both sets of data, I use the firm name, state location and sector. This merging process was performed with datasets that only contain the firm identifying variables, and not the R&D outcomes. The merge was done at INEGI's Microdata Laboratory to guard data security.

I begin by standardizing company names in both datasets. First I substitute all letters with an accent, such as "á" with the same letter without the accent ("a"). I also substitute "ñ" by "n". Then, I drop all special characters such as "&", "%", "-", etc. In addition, I drop all dots, commas, punctuation marks and blank spaces that are not between words. I also convert all letters to upper case. Finally, I drop all acronyms that denote the firm legal status, such as "SA DE CV", "SC DE RL", "AC", among many others.

Once names in both datasets are standardized, I use the company name, state location and sector to merge the firms. First I use the formal name. If I do not find an exact match with the formal name, I use the name shown at the establishment. If I do not find a match with the formal and establishment name within the state where the firm is located, I move to the other states until I find a match with either the formal or establishment name. The economic census dataset contains a registry of physical establishments. Since one firm can own many establishments and have them registered under the same name, merging by name can bring many establishment matches for the same firm in the PEI dataset. When this happens, I keep the firm main establishment, given that the state location and sector is matched.

There are many instances in which I cannot get an exact match using names. Company names might be misspelled in one, or both, datasets. To face this matter, I use the *recklink2* Stata command (Wasi and Flaaen, 2015). The command uses probabilistic matching and throws a set of likely matches ranked by a score. For those firms that I could not get an exact name match, I use this probabilistic matching. I follow the same process described above, i.e. merging by name, state location and sector. This process brings many probable matches for one firm. For each firm, I check its probable matches one by one and select the one I think is the best based on the name, location and sector.

Once the merging process across datasets was completed, INEGI provided a dataset with the firm R&D outcomes but without the firm identifiers. I use this dataset to evaluate the subsidy effects on the R&D outcomes. The evaluation analysis was also performed at the Microdata Laboratory to guard data security.

B Additional Tables and Graphs

Table B1: Estimates with the maximum grade as aggregation criterion

Outcome: Was there personnel working in innovation activities in 2013? (Yes=1, No=0)			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	0.391**	0.157	0.106
	(0.158)	(0.116)	(0.159)
	0.082 - 0.700	-0.070 - 0.385	-0.206 - 0.417
Two	0.129	0.171	-0.196
	(0.265)	(0.275)	(0.487)
	-0.390 - 0.648	-0.369 - 0.711	-1.153 - 0.761
Three	-0.179		
	(0.579)		
	-1.315 - 0.957		
Four	-0.468		
	(0.843)		
	-2.123 - 1.187		
Five	-0.619		
	(0.757)		
	-2.104 - 0.866		
Observations	1,207	1,070	761

Note: This table shows β estimates from equation (5) when I aggregate the firm grade using the maximum grade obtained in all its submitted projects. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table B2: Sharp RDD Estimates

Outcome: Was there personnel working in innovation activities in 2013? (Yes=1, No=0)			
	Full Sample	**± 30 points**	**± 15 points**
Polynomial order			
One	0.139***	0.122***	0.114**
	(0.035)	(0.040)	(0.047)
	0.070 - 0.208	0.044 - 0.200	0.021 - 0.207
Two	0.135***	0.127***	0.136**
	(0.039)	(0.043)	(0.056)
	0.059 - 0.211	0.042 - 0.212	0.027 - 0.246
Three	0.120***		
	(0.045)		
	0.033 - 0.208		
Four	0.125**		
	(0.049)		
	0.030 - 0.221		
Five	0.122**		
	(0.050)		
	0.025 - 0.220		
Observations	1,207	1,070	761

Note: This table shows β estimates from equation (2). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table B3: Estimates with a ±10 point window

Outcomes:	**Innovation Personnel**	**Research Personnel**	**Patenting Activities**	**Private RDI Spending**
Polynomial order				
One	0.397	0.296	0.259	0.016
	(0.325)	(0.471)	(0.408)	(0.023)
	-0.242 - 1.035	-0.630 - 1.222	-0.542 - 1.060	-0.030 - 0.061
Two	0.041	0.205	0.803	-0.020
	(0.506)	(0.737)	(0.628)	(0.034)
	-0.952 - 1.034	-1.243 - 1.653	-0.430 - 2.037	-0.088 - 0.048
Observations	523	523	523	140

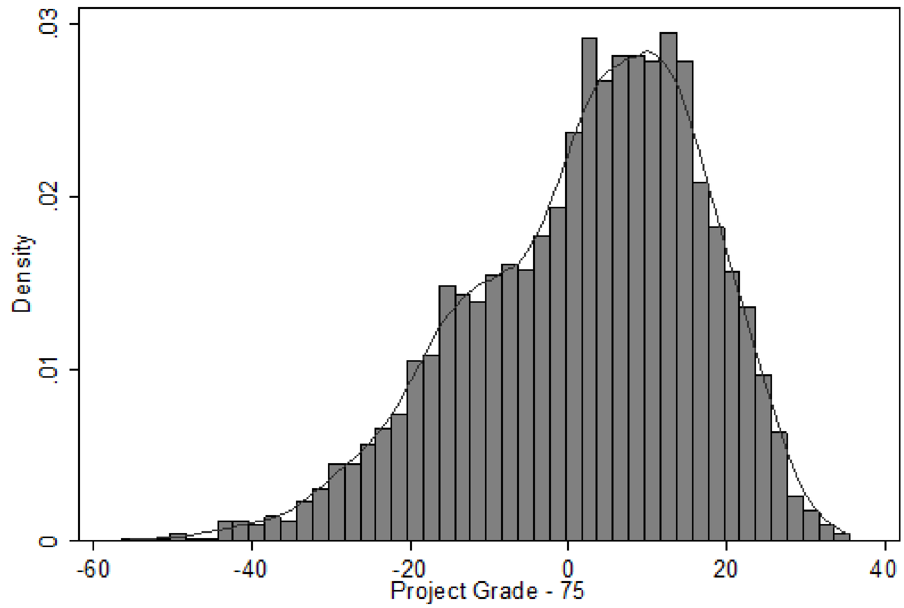
Note: This table shows β estimates from equation (5) with a window of ±10 points around the threshold. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Table B4: Estimates by firm size

Outcome: Was there personnel working on innovation activities in 2013? (Yes=1, No=0)						
	Large Firms			Small Firms		
	Full Sample	**± 30 points**	**± 15 points**	**Full Sample**	**± 30 points**	**± 15 points**
Polynomial order						
One	0.541***	0.297	0.278	0.462	0.437	1.370
	(0.204)	(0.198)	(0.260)	(0.482)	(0.391)	(2.041)
	0.141 - 0.942	-0.093 - 0.686	-0.232 - 0.789	-0.492 - 1.417	-0.338 - 1.212	-2.748 - 5.488
Two	0.232*	0.237	0.180	0.227	0.252	0.672
	(0.121)	(0.149)	(0.204)	(0.322)	(0.394)	(0.702)
	-0.005 - 0.470	-0.054 - 0.529	-0.220 - 0.581	-0.410 - 0.864	-0.529 - 1.033	-0.748 - 2.091
Three	0.317			0.289		
	(0.234)			(0.393)		
	-0.143 - 0.777			-0.489 - 1.067		
Four	0.248			0.581		
	(0.277)			(0.911)		
	-0.296 - 0.792			-1.222 - 2.383		
Five	-0.162			0.092		
	(0.358)			(0.613)		
	-0.865 - 0.541			-1.121 - 1.306		
Observations	993	886	437	133	112	46

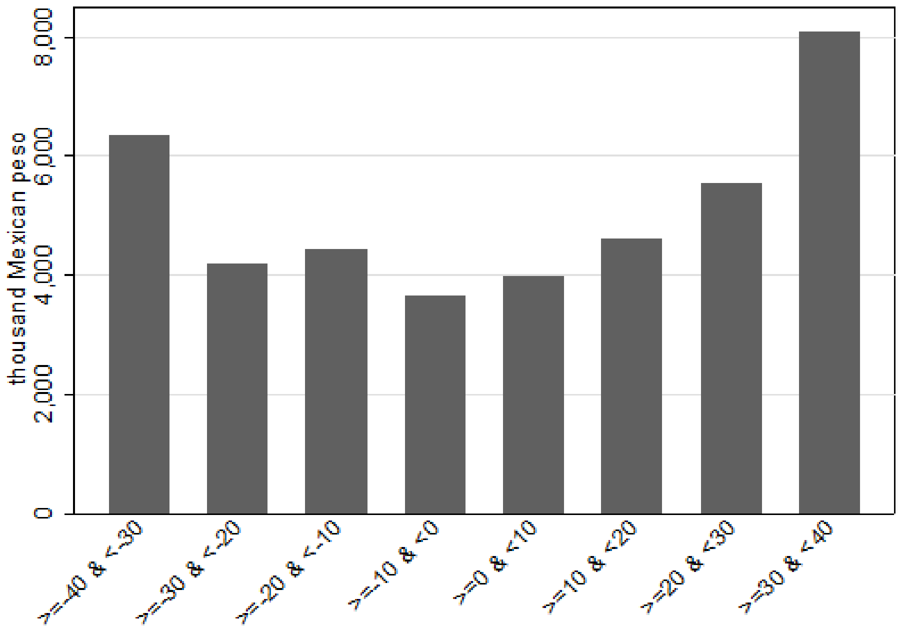
Note: This table shows β estimates from equation (5). I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Standard errors shown in brackets. Confidence intervals shown below standard errors. Stars show significance at the ***1%, **5% and *10% level.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census.

Figure B1: Distribution of project grades



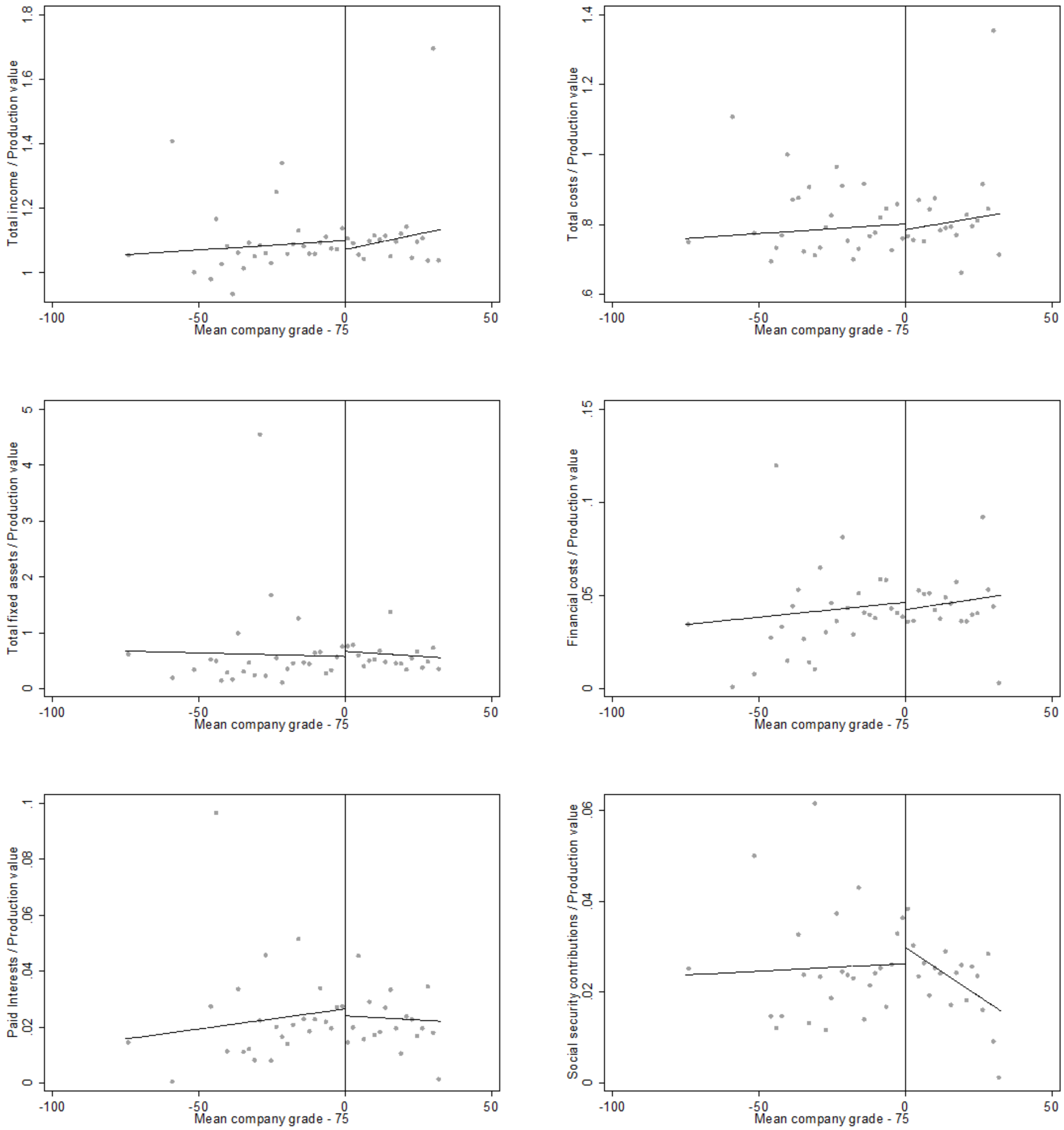
Note: This figure shows the density distribution of project grades. I include projects submitted to the PEI program from 2011 to 2013 of firms that I merged to the 2014 Economic Census databases.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

Figure B2: Mean subsidy amount by grade range



Note: This figure shows mean subsidy granted by ranges of firm mean grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census databases. Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

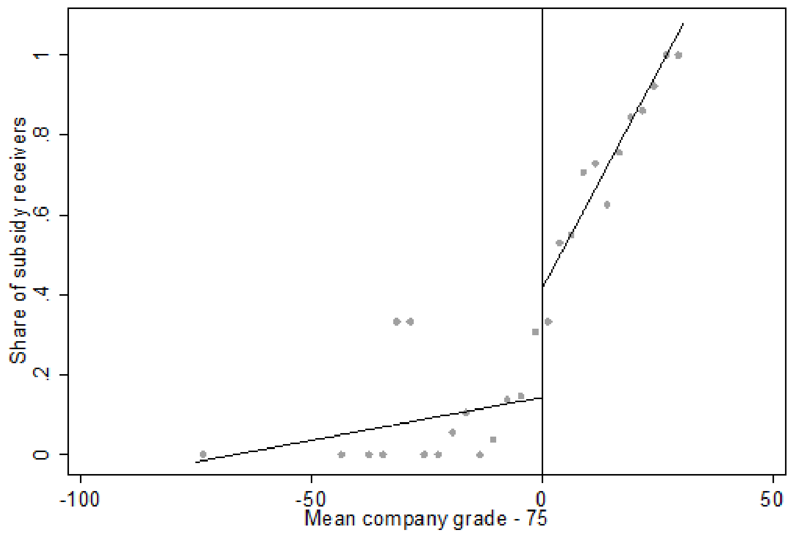
Figure B3: Variables non related to treatment



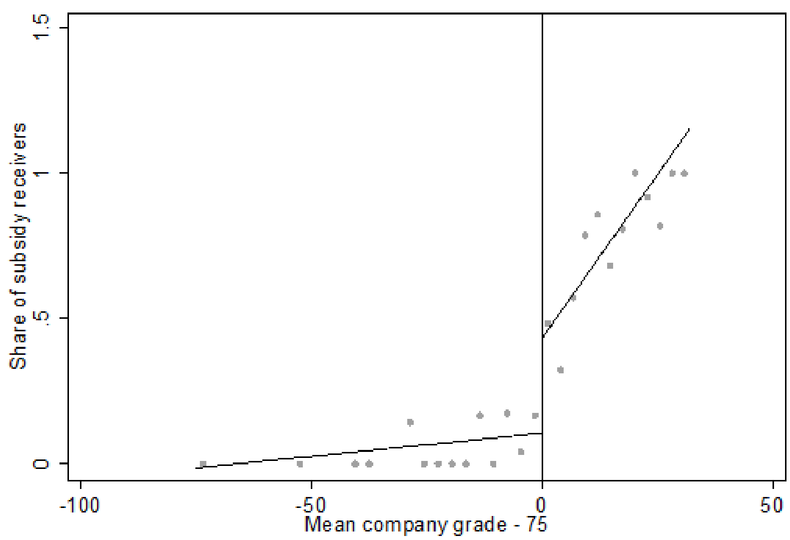
Note: This figure plots outcomes non related to treatment by mean firm grade. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.
Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

Figure B4: Share of firms that received the PEI subsidy by firm size

(a) Large firms



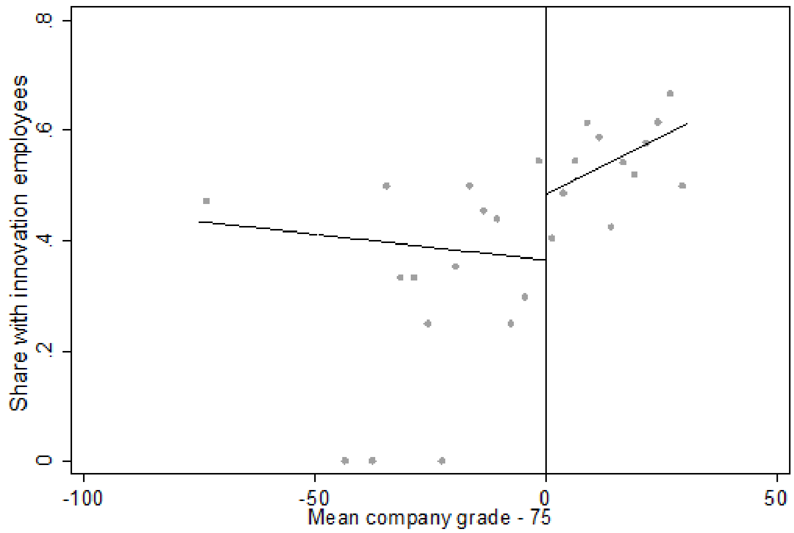
(b) Small firms



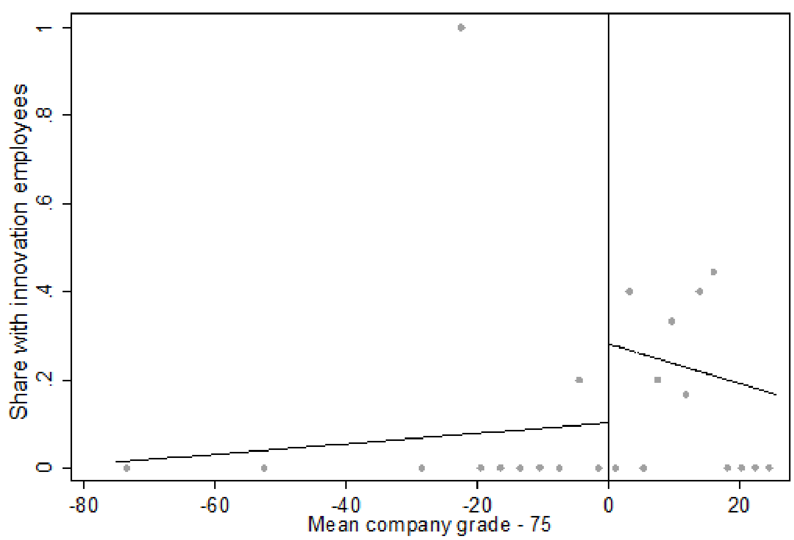
Note: This figure plots average subsidy reception by firm mean grade and by firm size. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census. Sources: CONACYT's PEI database and INEGI's 2014 Economic Census

Figure B5: Share of firms with innovation personnel by firm size

(a) Large firms



(b) Small firms



Note: This figure the average share of firms with personnel dedicated to innovation activities by firm mean grade and by firm size. I include firms that submitted a project to the PEI program from 2011 to 2013 that I merged to the 2014 Economic Census.

Sources: CONACYT's PEI database and INEGI's 2014 Economic Census