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Abstract[1]

This paper focuses on two research problems. The first is to measure the direct impacts of innovation support measures in Brazil, and the second is to test the hypothesis of indirect effects of innovation policies on non-beneficiary firms through the labor mobility channel, whether resulting from direct support programs or indirect support via tax incentives. For this purpose, mobility is defined as the movement of workers in technical-scientific occupations, as identified by Araújo et al. (2009). It is found that, with the exception of a subvention program, direct support in the form of credit or cooperative projects fosters more innovative effort than tax incentives. Nonetheless, direct and tax-based incentives for innovation have different purposes, and sound innovation relies on both types of incentive.

JEL classifications: D22, H32, H81, L52
Keywords: Industrial policy, Innovation, Brazil

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1. Introduction

Innovation is linked to long-term productivity, which is a crucial determinant of sustainable growth and development (IDB, 2012). However, firm innovation may occur on a socially sub-optimal scale without government intervention or support, due to two market failures (Hall, 2002): i) lack of appropriation: non-rivalry and the impossibility of blocking the diffusion of knowledge, which generates externalities from investment in knowledge creation that are not captured by the original investor; and ii) uncertainty of innovation projects and information asymmetry between innovators and the financial system, which may result in under-provision of innovation financing.

The government has three ways of supporting in-firm innovation. The first is by providing science and technology (S&T) infrastructure at universities and research institutes that produce basic science and train human resources. This way of supporting innovation is linked to the linear model of the innovation and S&T relationship, according to which businesses are considered agents external to the S&T system, since they are users, consumers, or adapters of the knowledge generated at universities or R&D centers.

The second way is through direct support to innovation, in the form of favorable credit terms, risk-sharing in innovation projects, venture or seed capital, collaborative projects with research institutes and universities, and subsidies (non-reimbursable grants to innovation). Direct funding to R&D may be targeted to projects that may have high rates of social return and where the gap between social and private rates of return may be wider (David, Hall, and Toole, 2000). Direct funding of R&D is a fast way to tie R&D to identified national priorities; it is also a way to provide support to small firms. David, Hall and Toole (2000) find that it is unlikely that direct subsidies displace private real R&D investments, except for the price effect of the induced demand for R&D inputs in an inelastic supply context. However, they recognize that the allocation of direct subsidies in practice may be subject to political pressure and lobbying.[2]

The third way that governments can support innovation is through tax incentives, which reduce the cost of doing R&D through tax exemptions, allowances, credits, tax deferrals, rate reduction, and so forth. Tax incentives are market based, since firms themselves make decisions

[2] David, Hall, and Toole (2000) argue that policymakers' concern about the success of, and attention to, their calls for innovation proposals may divert direct support to more profitable R&D investments that could be funded privately. They also note that prospective private payoffs make lobbying attractive.

about whether to engage in innovation and how much to invest in it. These incentives are available to all firms, regardless of sector, that use profits as their tax base, and the cost of administering them is low. These features explain why tax incentives have become a major trend in innovation policy in developed and developing countries alike.

One important caveat regarding tax incentives for R&D is that only profitable firms can take advantage of them. If a firm does not earn a profit in a given year, it is not subject to taxation and thus cannot recover its R&D investment through tax incentives. Additionally, tax incentives are not appropriate for small firms, which are generally taxed according to a simplified scheme using total revenues, not earned profits, as their tax base. Another obstacle to the use of tax incentives arises when countries impose a ceiling on tax credits or allowances. To overcome these problems, some countries allow firms to transfer R&D tax allowances or credits over time. When a single firm accumulates these allowances or credits for further use, it makes use of the carry-forward; when it uses past allowances or credits, it makes use of the carry-back.

David et al. (2000) argue that tax incentives may affect the composition of R&D. This is because incentives are likely to favor more profitable, short-run concerns and less risky innovation projects, rather than long-run projects that may have high rates of social return. Hence, according to these authors, these projects are expected to generate weaker spillover effects, at least when compared to long-run exploratory projects and investments in research infrastructure (which are rarely funded by tax incentives).

There does not seem to be a clear hierarchy in the types of support. Each of them targets a specific type of firm, and they have different objectives. Each country combines many instruments that support firm innovation in a coordinated way to constitute a productive development policy (PDP) in a broad sense.

After consolidating economic stabilization in the 1990s and readjusting the institutional structure to create a long-term basis for economic growth, since the late 1990s and early 2000s Brazil has endeavored to coordinate a number of policy measures aimed at systematically promoting industrial development. The first initiative was the 2003 Industrial, Technological, and Foreign Trade Policy (PITCE). Brazil passed its Innovation Law (2004) and Fiscal Incentives Law (*Lei do Bem*, 2005) under this initiative. The Innovation Law established the legal basis for cooperation between academia and business in the spirit of the American Bay-

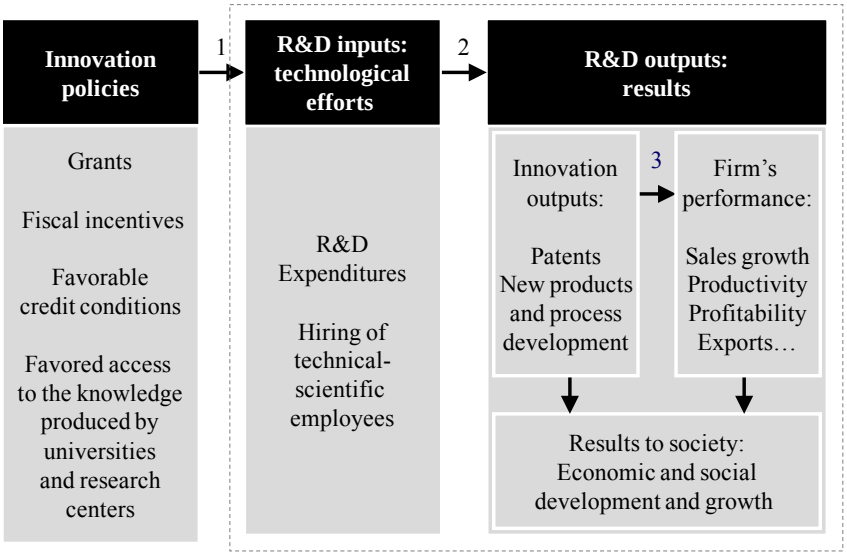
Dohle Act. The Fiscal Incentives Law made it easier to use tax incentives for innovation.[3] The PDP superseded the PITCE in 2008, and the current policy, launched in 2011, is known as the *Plano Brasil Maior*.

In the last ten years, a number of studies have focused on the impact of innovation policies on firm performance. The proliferation of studies may be related to the dissemination of public policies aimed at firms, as opposed to traditional S&T policies that focused mainly on science, not on technology or innovation. Other reasons include the availability of data and increased computational capacity, combined with the development of econometric techniques to assess the impacts of public policies.

Figure 1 summarizes the logic of innovation policy. As mentioned above, innovation policy comprises a variety of instruments (e.g., grants, fiscal incentives, and some sort of facilitated access to the knowledge produced by universities and research centers) to achieve its objective. These instruments directly affect innovation inputs, which include technological effort, and can be measured in terms of R&D expenditures or the number of technical-scientific employees, especially when the first variable is not available on a yearly basis. These innovation inputs are transformed into innovation outcomes. These outcomes can be immediate (innovations achieved, number of deposited or granted patents) or final, measured by a firm's performance (sales growth, productivity, employment growth, wages, and exports). These outcomes are "direct outcomes" because they are measured on firms that receive direct support. "Indirect effects" or externalities affecting the innovation environment are also expected to appear in firms that do not receive support from the program. These indirect effects are at the core of the justification for some innovation policies. However, they are difficult to measure. Therefore, most evaluations did not consider them.[4]

[3] Regarding the changes introduced by the Fiscal Incentives Law and its impacts on the B-index, a measure of tax price of R&D, see Araújo (2010).
[4] This is a severe, but unavoidable, limitation that can be easily extended to the evaluation of any public policy.

Figure 1. Logical Structure of the Research on the Impact of Innovation Policies on Firm Outcomes



Source: Araújo et al. (2010).

Most studies on this subject assess the impact of innovation policies on technological efforts (arrow 1, Figure 1). These analyses hardly touch on what has been called "firm performance" (arrow 3, Figure 1). In fact, the relationship between technological effort, innovation, and performance is not necessarily linear. Hence, in these analyses, sequence does matter. Additionally, the path dependency cannot be captured using time dummies, and the time intervals required to convert technological efforts into innovations and innovations into improved performance may differ as a result of the very nature of the innovation process. Finally, the intrinsic risks in innovation activities may simply mean that a significant share of the projects do not have positive impacts.

Brazil supports firms both directly and indirectly. Direct support includes grants, credit on favorable terms, and collaborative projects with research institutes and universities. The most important innovation agency related to direct support is FINEP (*Financiadora de Estudos e Projetos*), linked to the Ministry of Science, Technology, and Innovation. FINEP's annual budget increased eightfold in local currency in the 2000s. Indirect support is provided through tax incentives. In this sense, Brazil is the fifth most generous country in the world (behind Spain, Mexico, China, and Portugal), subsidizing R&D through tax incentives: 27.3 percent of R&D expenditures are subsidized (Araújo, 2010).

In Brazil, some studies have evaluated the impact of FINEP's support measures on its beneficiaries. All of them employed quasi-experimental techniques, and all of them rejected the crowding-out hypothesis. Table 1 summarizes these studies. The first three articles use the "treatment" approach in the binary form (i.e., only access matters, and they compare treated vs. non-treated) and the last one takes into account the possible dosage effect (i.e., the size of the grant or credit may matter for innovation efforts). Alvarenga (2012) found that impacts of Sectoral Funds on firms' innovation efforts and performance are U-shaped with respect to size, with greater impact on very small and large firms.

Table 1. Summary Table of Evaluation Impacts of FINEP's Support

Authors	Technique	Period	Main features	Dependent variables	Main Findings
De Negri, De Negri and Lemos (2008)	*Propensity Score Matching* with level differences.	1996-2000 (R&D expenditures), 1996-2003 (other variables).	Comparison with different control groups (all firms, innovative firms and firms holding patents)	R&D expenditures, total sales, number of employees, labor productivity and patents	ADTEN (a FINEP's credit program) firms invested 60% more than non-ADTEN firms. Significant impacts on firm's growth, as measured by total sales or number of employees, but no significant impacts on productivity and patents
Avellar and Kupfer (2008)	*Propensity Score Matching* with level differences and diff-in-diff.	2000-2003	Assessment of three programs: PDTI (tax incentives), ADTEN (credit) and cooperative FNDCT (matching grants).	R&D expenditures and R&D effort (R&D/total sales).	PDTI and ADTEN induce higher R&D expenditures, but R&D/total sales were not affected by the programs. Inconclusive results for cooperative FNDCT.
Araújo et al. (2010)	*Propensity Score Matching* level differences and *diff-in-diff.*	2001-2006	Treatment variable is access to sectoral funds. The authors used the technical-scientific personnel as a proxy for R&D expenditures.	Technical-scientific personnel as a proxy for R&D, number of employees and high tech exports.	The access to sectoral funds induce higher innovation efforts, and firms that access the sectoral funds also grow faster in two years after their first operation with FINEP. No impacts on high-tech exports.
Alvarenga (2012)	*Generalized Propensity Score Matching* combined with dosage-response function, in level and diff-in-diff.	2001-2006	This is the first article that considers the access to FINEP not as a binary variable, takes into account the possible dosage-effects.	The same as in Araújo et al. (2010)	U-shaped Dosage-response curves. To overall firms, 1% more of Sectoral Funds' resources lead to a 1.6% increase in innovation efforts.

Source: Authors' compilation.

The main concern of the impact evaluation literature on innovation support has been the impact of innovation effort or firm performance. Regarding the innovation effort, the basic question has been whether a dollar increase in public R&D funding leads to more than a dollar increase in private R&D investment. This is known as the "bang-for-the-buck" hypothesis. Roughly speaking, the "one-to-one rule" prevails in most papers (David, Hall, and Toole, 2000). In other cases, researchers are interested in the cost effectiveness of the public policy.

Innovation policies are often justified by their possible spillovers. However, this issue has not been addressed in the literature. Castillo et al. (2013) studied the spillover effect of innovation policy in Latin America. They estimated the indirect effect of the FONTAR program in Argentina using labor mobility as a source for spillovers. The measurement of spillovers may affect the cost-benefit balance of these policies. In the presence of externalities, the cost effectiveness of the policy does not require the "one-to-one rule" (Mohnen and Lokshin, 2009), and even if beneficiary firms fail to innovate, other firms may learn from their failures.

One way that spillover may occur is through labor mobility, especially skilled labor or researchers. These skilled workers may move from one firm to another and carry knowledge with them. If one researcher works in a firm that invests more in knowledge generation due to innovation policies, the mobility of this researcher may bring about some knowledge transfer, and another firm then invests more in knowledge generation. Thus, one must take this spillover into account as a positive impact of government support.

This paper focuses on two research problems. The first is to measure the direct impacts of innovation support measures. The second is to test the hypothesis of indirect effects of innovation policies on non-beneficiary firms through the labor mobility channel, resulting from direct support programs or indirect support via tax incentives. For this purpose, mobility is defined as the movement of workers in technical-scientific occupations. Technical-scientific occupations have been identified in Araújo et al. (2009).

2. Innovation Policy in Brazil

2.1 FINEP's Direct Support Programs and Sectoral Funds

The Funding Authority for Studies and Projects (*Financiadora de Estudos e Projetos*—FINEP) is the main agency that promotes innovation in Brazil. It was established in 1967, during a wave of

institution building to support innovation.[5] Today, it is linked to the Ministry of Science, Technology, and Innovation. FINEP's funding comes from several sources: i) the federal budget, ii) Sectoral Funds, and more recently, iii) the Employee Assistance Fund (*Fundo de Amparo ao Trabalhador*—FAT). Resources from FAT come from corporate taxes on firms' profits (PIS-COFINS). FAT's funding to FINEP is expected to rise by more than US$1 billion a year. Sectoral Funds are financed by special taxes on certain economic activities, such as electricity, telecommunications, oil exploration, and others. They provide stable R&D funding for 14 strategic sectors, in addition to two special funds aimed at promoting university-business partnerships and upgrading research infrastructure in universities and PRIs, respectively.

The novelty of the initiative was that R&D funding would no longer be subject to budget cuts, and administration and funding allocation would be decided by tripartite councils composed of scholars, public officials, and entrepreneurs. In fact, funding from the S&T Sectoral Funds has risen steadily in the last years, and today they are among the most important sources of innovation funding in Brazil.

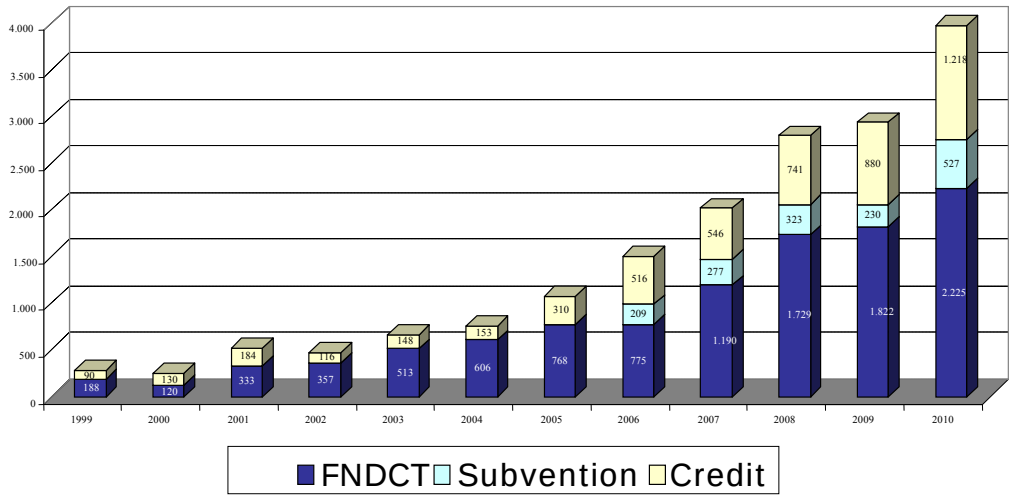
FINEP's total budget for 2010 was US$2.25 billion. The budget more than doubled compared to 2009 and 2008 in local currency. In the last decade, there has been an eightfold increase in FINEP's budget (Figure 1). From the 2010 amount, the largest share (US$1.26 billion) went to the National Fund for Scientific and Technological Development (FNDCT), which is targeted at research infrastructure, mainly in universities. US$690 million went to credit operations, and US$299 million went to direct subsidies. Since 2003, FINEP has managed to raise its budget execution rate to almost 100 percent.

Approximately 60 percent of the 2010 budget was allocated to FNDCT. In turn, the introduction of the economic subvention mechanism stipulated in the Innovation Law resulted in a greater share of resources from FINEP for business activities. Before the introduction of the economic subvention program, around 30 percent of FINEP's resources were intended for

[5] In this wave, there was also the establishment of BNDES' Technical-Scientific Development Fund (FUNTEC) in 1964, the National S&T Development Fund (FNDCT) in 1969, and the National Institute for Industrial Property (INPI) in 1970. The Brazilian Agricultural Research Corporation (Embrapa) was established in 1973 to develop research in agriculture and disseminate state-of-the-art planting techniques. A large part of Brazil's success in agriculture may be credited to Embrapa's research and development. The world's third-largest airplane manufacturer, the Brazilian Aeronautical Corporation (Embraer), was founded in 1969, benefiting from research and human resources from the Technological Center of Aeronautics and the Technological Institute of Aeronautics.

companies in the form of credit on more favorable terms. With the grant, the amount of resources devoted to companies increased to 40 percent.

Figure 1. FINEP's Disbursements, by Support Modality (in local currency (BRL) millions)



Source: FINEP.

Firms can access FINEP support in three ways: i) by being a partner in a research institute-enterprise cooperation project; ii) by applying for a subsidized innovation credit (the funding for this kind of operation does not come totally from the Sectoral Funds, but the implicit subsidy in the lower interest rates does); or iii) by applying for an economic subvention or direct subsidy (this type of support began in 2004 after Innovation Law). The support is project-based, and firms and research institutions must participate in a public call for proposals. A council comprising scholars, public officials, and entrepreneurs decides which projects will be approved.

Hence, data on direct support measures are administrative records of cooperative projects with universities (a kind of grant), credit under special conditions, and economic subvention or non-reimbursable subsidies. Credit under special conditions may be available to firms in the form of FNDCT, ADTEN (*Programa de Apoio ao Desenvolvimento Tecnológico da Empresa Nacional*), or reimbursable credit (*reembolsável*). Although cooperative projects with universities are, in theory, a different kind of support, there is some evidence that informal arrangements between entrepreneurs and academics to access *interveniente* funds, in exchange

for overhead at a university, were typical until recently.[6] Information on these types of support is available from 2000 to 2008, and they were aggregated as a "direct support" treatment variable.

Economic subvention or non-reimbursable subsidies were introduced by the Innovation Law in 2004 and made available to firms in 2006. Data are available between 2006 and 2008, and since its time span is different from that of "direct support," it will be dealt with separately. Moreover, subvention beneficiaries are different from the others, since the program is targeted at small firms.

2.2 Innovation Support through Tax Incentives: Lei do Bem

In Brazil, tax incentives for R&D expenditures were introduced in 1993 by Law 8.661/93. These tax incentives mainly targeted the industrial and agricultural sectors, through the Program for Technological Development of Industry (*Programa de Desenvolvimento Tecnológico da Indústria*—PDTI) and the Program for Technological Development of Agriculture (*Programa de Desenvolvimento Tecnológico da Agricultura*—PDTA), respectively. Between 1994 and 2004, tax incentives provided by the PDTI and PDTA benefited a small group of firms. There are three reasons for the limited uptake: i) innovation projects needed to be pre-approved; ii) tax incentives were biased towards large firms due to special tax legislation according to which small firms could not deduct their innovation expenditures from their taxable profits; and iii) tax incentives had a ceiling of 4 percent of corporate tax duty. Informality also played some role in the bias towards large firms.

Brazil reformulated its institutional framework to foster innovation in 2004 and 2005. The Innovation Law of 2004 and the Fiscal Incentives Law (*Lei do Bem*) in 2005 loosened some institutional barriers, provided incentives to firm-university cooperation, and modified the way that firms accessed tax incentives to a rather automatic use subject to *a posteriori* audits. In addition, the incentive ceiling was removed.

These changes made access to fiscal incentives simpler and more attractive. According to Araújo (2010), the introduction of the *Lei do Bem* and its change in 2008 made Brazil the fifth most generous country in the world in terms of implicit subsidies to R&D in the form of tax incentives. According to the B-index approach,[7] the implicit subsidy through tax incentives to R&D expenditures is currently 29.5 percent for large firms and 18.1 percent for SMEs. A record

[6] See the reports of De Negri and Kubota (2008).
[7] Regarding B-index methodology and calculations, see Warda (2001).

of *Lei do Bem* beneficiaries is available from 2006 to 2010, and most beneficiaries are large firms.

2.3 Mobility of Technical-Scientific Workers

Worker mobility is one of the channels through which spillovers may occur. However, not all transfers of human capital generate spillovers. First, not every worker takes away specific knowledge that might be important for promoting innovation elsewhere. We assume that a natural candidate to carry knowledge and generate spillovers is an R&D worker, or "PoTec."Second, workers need to have worked for a sufficient amount of time in the company to absorb specific knowledge. Therefore, spillover effects cannot be expected from every movement. Moreover, high turnover may be related to low skills. We assume, then, that workers must remain in a beneficiary firm for at least two years before moving on in order to generate spillovers in non-participant firms.

Technical-scientific employees—henceforth PoTec—are proxies for R&D inputs (or technological efforts) and are also the channel for possible spillovers through labor mobility. This proxy for technological efforts has been suggested by Araújo, Cavalcante and Alves (2009) to overcome some of the practical problems of relying on innovation survey data, such as the Brazilian PINTEC, to measure innovation inputs. The first problem is related to timing: innovation survey results are usually released with some delay, and they typically collect quantitative data only for the survey's last year of reference.[8] The second problem is related to the sampling scheme. Innovation surveys are sample surveys, and when one matches administrative registers from support programs and sample surveys, a lot of information may be lost because beneficiaries were not interviewed during the survey round. Moreover, in Brazil it is not possible to form a panel of firms from PINTEC, except for those very large—and very few—firms that are interviewed in every round of the innovation survey (those with 500 or more employees).

The option for the PoTec as a proxy for the technological efforts follows the pioneering study by Blank and Stigler (1957). It is related to the fact that most R&D expenditures are comprised of the wages of researchers. Hence, PoTec is simply defined as the sum of the number

[8] In Brazil, R&D expenditures from PINTEC are only available for 2000, 2003, 2005, and 2008.

of researchers, engineers, R&D directors and managers, and scientific professionals in each firm. In practice, the following occupational groups of the Brazilian Classification of Occupations (CBO) were considered:

Table 2. Occupational Groups of PoTec

Occupational group	Professionals
Researchers	Researchers
Engineers	Mechanical and electrical engineers Civil engineers, among others Agronomists and fishing engineers
R&D directors and managers	R&D directors R&D managers
"Scientific" professionals"	Biotechnologists, geneticists, metrology researchers, and specialists in meteorological calibrations Mathematicians, statisticians, among others IT and computer professionals Physicists, chemists, among others Biologists and other professionals

Source: Araújo, Cavalcante and Alves (2009).

Originally proposed by Gusso (2006) and adjusted afterwards by Araújo, Cavalcante and Alves (2009), the typology presented above has a correlation coefficient with internal and external R&D expenditures higher than 90 percent. Therefore, PoTec is an appropriate proxy of technological effort. Since PoTec can be calculated based on the data from the Annual List of Social Information (RAIS), we can follow its yearly evolution during the period considered in this study.

In short, mobility is defined as follows: PoTecworkersmustremain at least two years in a participant firm after it receives some support for innovation. This indicates that workers must have learned something from the supported innovation project. Indirect beneficiaries are defined as firms that did not receive any kind of innovation support but that hired PoTec workers who worked at least one year in beneficiary firms after these firms received innovation support.[9]

2.4 Description of the Datasets and Data Treatment

We use administrative records from the different programs, the Annual List of Social Information (*Relação Anual de Informações Sociais*—RAIS) from the Ministry of Labor, and

[9] Since we deal with annual databases, there must be a difference of two years between the datasets to ensure that a single worker remained at least one year at the origin firm.

foreign trade data from the Secretary of Foreign Trade (SECEX) in the Ministry of Development, Industry, and Foreign Trade (MDIC).

The administrative records of the programs include: ADTEN, FNDCT, *reembolsavel*, *interveniente* (cooperative projects with universities), subvention and *Lei do Bem* (tax incentives). For ADTEN, FNDCT, and *reembolsavel*, data are available between 2000 and 2008. For *interveniente*, data are available between 2002 and 2008, because the program was created in 2002. Subvention and *Lei do Bem* programs began in 2006, so data on subvention beneficiaries comprise the period 2006-2008, and *Lei do Bem*, 2006-2010.

RAIS is an administrative record of the labor force profile, which is mandatory in Brazil for all firms, regardless of sector. RAIS is a matched employer-employee database comprised of information on every formal worker in Brazil, including gender, age, occupation (according to the Brazilian Occupations Classification), wages, time in company, and educational level, among others. The final database also contains information on exports and imports provided by the administrative records of SECEX. Variables found in these datasets and their time spans are briefly described in Table 6.

This analysis was restricted to industrial firms with more than five employees and which remained in the RAIS database for at least two consecutive years. Table 3 shows the number of beneficiaries after merging these datasets. Table 4 shows the average size of the support.

Table 3. Number of Direct Beneficiaries of Innovation Support Programs, 2000-2010

Program	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Interveniente	.	.	59	29	74	65	87	13	10	-	-
Reembolsavel	13	12	13	9	4	24	27	25	23	-	-
Subvention	.	.	.	.	.	.	57	53	60	-	-
ADTEN	19	14	22	18	6	14	.	.	.	-	-
FNDCT	7	6	53	17	67	8	.	.	.	-	-
Lei do Bem	.	.	.	.	.	.	107	242	349	406	476

Source: Authors' compilation.

Table 4. Size of Innovation Support Programs, 2000-2008

Year	Number and average size of the support (in US$ thousands)	**Credit (reem-bolsável)**	**Cooperative projects (Interveniente)**	**Sub-vention**	**ADTEN**	**FNDCT**	**Tax Incentives (Indirect Support)**	**Inno-vation Support (any kind)**
2000	number	6	-	-	10	7	-	**17**
	size	735.2	-	-	658.7	189.8	-	**725.1**
2001	number	10	-	-	9	1	-	**12**
	size	2,232.9	-	-	327.7	4.213.2	-	**2.457.6**
2002	number	3	25	-	8	22	-	**33**
	size	846.4	207.3	-	804.8	102.0	-	**497.1**
2003	number	7	21	-	9	3	-	**31**
	size	1,031.4	198.6	-	635.6	84.1	-	**560.1**
2004	number	2	47	-	2	32	-	**59**
	size	1,132.6	208.1	-	1,132.6	125.5	-	**310.6**
2005	number	6	42	-	3	5	-	**53**
	size	2,371.0	426.7	-	2,808.4	409.7	-	**804.1**
2006	number	21	54	47	-	-	21	**137**
	size	2,.535.5	328.7	607.1	-	-	186.8	**755.1**
2007	number	13	8	41	-	-	48	**110**
	size	863.1	120.1	669.4	-	-	231.0	**461.1**
2008	number	13	8	57	-	-	90	**162**
	size	1,983.2	639.9	1,122.9	-	-	660.7	**952.9**

Source: Authors' compilation.

After running the algorithms to track PoTec mobility, we defined the indirect beneficiaries of innovation support programs through labor market channels. The number of these indirect beneficiaries per program is indicated in Table 5. There may be double counting in this table (i.e., one firm may hire PoTec workers from beneficiaries of *reembolsavel* and ADTEN). Another interesting feature of Tables 3 and 5 is that the number of *Lei do Bem* beneficiaries grows quickly, indicating that tax incentives are becoming popular in Brazil. Moreover, these firms tend to be large. Consequently, the probability that at least one PoTec worker moves is relatively higher, which generates a large number of indirect beneficiaries.

Table 5. Number of Indirect (or Spillover) Beneficiaries of Innovation Support Programs, 2000-2010

Program	2002	2003	2004	2005	2006	2007	2008	2009	2010
Interveniente	.	.	62	38	75	71	182	35	18
Reembolsavel	5	3	45	10	.	41	16	26	22
Subvention	.	.	.	.	.	.	129	68	55
ADTEN	9	3	51	19	12	29	.	.	.
FNDCT	6	20	76	38	101	13	.	.	.
Lei do Bem	.	.	.	.	.	.	252	532	917

Source: Authors' compilation.

Table 6. Summary of Data Used in the Research Project

Database	Acronym	Data Source	Data availability	Sample design	Description/variables
Employee-level survey	RAIS	Ministry of Labor – MTE	Yearly (1991-2010)	Data refer to employees in all firms in Brazil, and they come from a mandatory questionnaire all firms in Brazil must fill out every year.	For each employee, there is information about the job posting: occupation, time on the job, wages, ages of schooling, and the firm he or she is working for. For firms, we have information on the location, sector, and number of affiliates and subsidiary firms, and information derived from employee-level data.
Foreign trade data	SECEX	Ministry of Development, Industry and Foreign Trade – MDIC	Monthly **(**1993-2007). Information available on export dummies and values on yearly basis from 2008 to 2010	Originally, data refer to export or import transactions. These data are administrative records.	For each foreign trade transaction, there is information on the value, destination/source, harmonized system description of the product (this is what allows the classification according technological intensity), weight, and transport information.
Lei do Bem (Tax Incentives)	-	Ministry of Science, Technology and Innovation	2006-2010	Registry of firms which used tax incentives for innovation	The database has also the amount of the supported innovation projects, and the tax exemption related to it.
FINEP Data	-	FINEP and Ministry of Science, Technology and Innovation	2000-2008	Registry of firms which accessed the ADTEN, FNDCT, *Reembolsavel,* Cooperative projects and subvention.	The observational unit is the project approved. The database comprises the year of submission and approval, the grant size, a short description of the project and the kind of engagement into the project, by firms and universities.

Source: Authors' compilation.

As shown in Table 7, the distribution of average size confirms the hypothesis that tax incentives are designed for large firms. Among the beneficiaries, 48 percent of them have more than 500 employees. Nonetheless, in Brazil credit incentives are accessed by large firms as well. Subvention is the remarkable exception: 41 percent of beneficiaries have fewer than 30 employees. However, the distribution of indirect beneficiaries according to size is biased towards larger firms, even in the case of subvention indirect beneficiaries, as shown in Table 8. This may be due the fact that PoTec workers, when switching jobs, tend to choose larger firms

Table 7. Size Distribution of Direct Beneficiaries of Innovation Support Programs, 2000-2008

Size category	int.	%	reemb.	%	ADTEN	%	FNDCT	%	subvention	%	*Lei do Bem*	%
<30	57	17%	16	11%	4	5%	16	12%	69	41%	21	3%
30<=emp<50	28	9%	13	9%	7	8%	6	5%	22	13%	19	3%
50<=emp<100	35	11%	17	11%	8	10%	13	10%	21	12%	63	9%
100<=emp<250	48	15%	23	16%	10	12%	23	18%	19	11%	142	19%
250<=emp<500	45	14%	29	20%	17	20%	24	18%	10	6%	137	19%
emp>=500	116	35%	50	34%	38	45%	48	37%	29	17%	350	48%
Total	329		148		84		130		170		732	

Source: Authors' compilation.

Table 8. Size Distribution of Indirect (Spillover) Beneficiaries of Innovation Support Programs, 2002-2010

size class	int.	%	reemb.	%	ADTEN	%	FNDCT	%	subvention	%	*Lei do Bem*	%
<30	19	5%	5	3%	3	3%	7	3%	9	4%	106	9%
30<=emp<50	17	4%	2	1%	1	1%	10	5%	9	4%	69	6%
50<=emp<100	27	7%	10	6%	11	10%	11	5%	19	8%	151	12%
100<=emp<250	64	16%	22	14%	22	20%	30	15%	51	22%	227	19%
250<=emp<500	72	18%	27	17%	19	17%	36	18%	32	14%	212	18%
emp>=500	206	51%	91	58%	54	49%	107	53%	112	48%	444	37%
Total	405		157		110		201		232		1,209	

Source: Authors' compilation.

Other characteristics of direct and indirect beneficiaries are shown in Tables 9 and 10. As expected, these characteristics confirm the hypothesis that both direct and indirect (spillover) beneficiaries of innovation support programs are very different from the rest of industrial firms in many ways. They tend to be not only larger, but they also pay higher wages, have a more educated labor force, and tend to export more.

Table 9. Characteristics of Direct Beneficiaries of Innovation Support Programs, 2000-2007

Variables	Rest of industrial firms	Credit (reemb.)	Int.	Subvention	ADTEN	FNDCT	Lei do Bem (tax incentives)	Innovation Support (any kind)
number of firms (average per year)	118,963	10	29	48	7	12	53	77
Number of Employees (average)	24.3	289.8	258.3	93.3	319.5	178.5	586.4	306.0
Share of exporters (% of total)	5.2%	63.0%	44.4%	39.3%	53.7%	58.6%	81.1%	55.5%
Share of importers (% of total)	4.7%	63.0%	49.3%	47.6%	61.0%	61.4%	90.6%	61.7%
PoTec	0.3%	3.5%	3.5%	7.3%	4.1%	3.9%	3.2%	4.3%
Average wages (direct support=100)	41.8%	101%	91%	112%	88%	99%	176%	120%
Average years of schooling of the labor force	8.1	10.2	9.8	10.9	9.7	9.8	10.5	10.3

Source: Authors' compilation.

Table 10. Characteristics of Indirect (Spillover) Beneficiaries of Innovation Support Programs, 2000-2007

Variables	Rest of industrial firms	Credit (reemb.)	Int.	Subvention	ADTEN	FNDCT	Lei do Bem (tax incentives)	Innovation Support (any kind)
number of firms (average per year)	118,963	9	45	70	12	20	129	68
Number of Employees (average)	24.3	718.9	1023.0	830.1	883.8	665.1	1,332.9	947.4
Share of exporters (% of total)	5.2%	74.6%	72.3%	77.1%	73.2%	61.0%	76.7%	71.4%
Share of importers (% of total)	4.7%	85.7%	81.3%	87.1%	83.1%	77.1%	87.6%	81.3%
PoTec	0.3%	2.5%	4.7%	4.1%	3.3%	5.4%	3.8%	4.3%
Average wages (direct support =100)	41.8%	74.5%	106.4%	106.6%	71.0%	123.6%	105.5%	105.5%
Average years of schooling of the labor force	8.1	10.2	10.6	11.2	10.1	10.9	10.7	10.6

Source: Authors' compilation.

Tables 9 and 10 show that the number of beneficiaries (both direct and indirect) is very low compared to the total number of industrial firms. Moreover, beneficiaries are far from directly comparable to the rest of non-beneficiary firms, at least on average. As can be seen in Table 12, restricting non-beneficiaries to the combinations of sector (CNAE[10] 2-digit level) and state (27 states in Brazil) where there was at least one beneficiary (direct or spillover) in the whole time span under analysis, reduces the whole sample to almost 33 percent of observations.

Hence, the econometric analysis is conducted on three different unbalanced panel databases. One is for direct support instruments, which comprise ADTEN, FNDCT, credit (*reembolsavel*), and cooperative projects (*interveniente*). This database ranges from 1999 to 2010. Programs themselves range from 2000 to 2008, but the baseline was set one year before the first innovation support operation because of the econometric models which use lagged variables. Additionally, since there are spillover beneficiaries—which, by definition, require a two-year period of PoTec workers at the origin firm—the database goes until 2010, that is, two years after the last support operation for which data are available. Moreover, we may be interested in measuring the performance of direct beneficiaries after some time receiving the innovation support.

Following the same logic, separate databases were created for *Lei do Bem* (tax incentives) and subvention direct or spillover beneficiaries. In the case of *Lei do Bem*, information on direct beneficiaries in 2009 and 2010 is available. Thus, in these two years, direct and spillover beneficiaries coexist. The same cannot be said regarding subvention, for which information on direct beneficiaries is only available until 2008. As in the case of direct support, in both cases the baseline was set one year before the programs began operating, that is, 2005. The databases were constructed in a way that there is no intersection between the three treatments except in the first case (direct support). Hence, both databases (*Lei do Bem* and subvention) cover the period 2005-2010.

[10] CNAE (*Classificação Nacional de Atividades Econômicas*) is the Brazilian sectoral classification. It is comparable to the SIC (Standard Industrial Classification).

Table 11. Sample for the Evaluation: Direct Support (ADTEN, FNDCT, Credit or Cooperative Projects): 2000-2010

Year	Total of industrial firms per year	Total of industrial firms per year - more than 5 employees	Total of industrial firms per year - more than 5 employees and 2 consecutive years in the database	Total of industrial firms - in the same combinations of sector/state as beneficiaries (sample for evaluation)	Number of ADTEN, FNDCT, Credit or Cooperative Projects beneficiaries
2000	225,434	104,146	99,382	77,456	26
2001	231,883	108,719	104,012	77,452	22
2002	239,420	113,217	108,908	77,514	84
2003	243,912	116,348	111,993	77,483	53
2004	251,841	121,432	116,595	77,532	102
2005	260,186	127,509	122,736	77,529	99
2006	257,256	127,897	116,796	77,544	114
2007	263,667	132,435	120,981	77,468	38
2008	273,552	138,036	126,043	77,463	33
2009	279,746	139,486	127,910	99,709	.
2010	299,008	147,433	139,353	108,357	.

Source: Authors' compilation.

Table 12. Sample for the Evaluation: Lei do Bem (Tax Incentives): 2006-2010

Year	Total of industrial firms per year	Total of industrial firms per year, more than 5 employees	Total of industrial firms per year - more than 5 employees and 2 consecutive years in the database	Total of industrial firms in the same combinations of sector/state as beneficiaries (sample for evaluation)	Number of Lei do Bem beneficiaries
2006	257,256	127,897	116,796	93,064	107
2007	263,667	132,435	120,981	96,251	242
2008	273,552	138,036	126,043	100,249	349
2009	279,746	139,486	127,910	101,680	406
2010	299,008	147,433	139,353	110,530	476

Source: Authors' compilation.

Table 13. Sample for the Evaluation: Subvention 2006-2010

Year	Total of industrial firms per year	Total of industrial firms per year - more than 5 employees	Total of industrial firms per year - more than 5 employees and 2 consecutive years in the database	Total of industrial firms - in the same combinations of sector/state as beneficiaries (sample for evaluation)	Number of subvention beneficiaries
2006	257,256	127,897	116,796	54,556	57
2007	263,667	132,435	120,981	56,057	53
2008	273,552	138,036	126,043	58,337	60
2009	279,746	139,486	127,910	58,833	,
2010	299,008	147,433	139,353	63,398	,

Source: Authors' compilation.

2.5 Outcome Variables

Following the scheme displayed in Figure 1, we are especially interested in the impacts on innovation inputs, measured by a firm's technical-scientific personnel. PoTec is measured in three ways: i) in binary form (whether a firm has PoTec or not); ii) in logs; or iii) as the log of the share of PoTec to total employees.

The main performance variable is export performance. Export performance is measured in two ways: i) as dummy variables for exporting; and ii) exports per employee.

Some other performance variables are size, measured as the number of non-PoTec employees, and productivity, proxied by real wages. This proxy has evident limitations. For example, it does not account for circumstances in which innovation activities lead to an increase in labor productivity, or where productivity increases are not translated into higher wages in the short run. When considering a model of labor demand, based on a production function with labor and capital, there may be some interesting results if we control for capital. However, this variable is not our database; rather, it is proxied by the log of imports of capital goods, and it is included as a control for wage equations whenever possible. The results are shown in the Appendix. Productivity (real wages) is measured in logs or as the first-difference in logs.

2.6 Identification Strategy

Firms make a series of decisions with respect to their participation in public programs. These decisions are not necessarily consecutive. First, firms decide to invest in innovation activities. Second, they decide to apply for public support, and they type of support that they need. Even in the case of tax credits, which are supposedly available to all innovators, the *Lei do Bem* covers less than 10 percent of the 6,000 firms doing R&D in Brazil every year, probably due to barriers to information and compliance costs of following the rules of the program. Third, firms decide when to participate. Firms participating in these programs are usually the ones that would have the largest expected outputs in the absence of the program. Therefore, the simple comparison between beneficiaries and non-beneficiaries might not reflect the program's causal effect on firm performance. To make them more comparable, we restricted non-beneficiaries to the combinations of sector (CNAE[11] 2 digit-level) and state (27 states in Brazil) where there was at least one beneficiary (direct or spillover) in the whole time span under analysis.[12] The resulting figures when firms are restricted to these sector*state combinations are shown in Table 12.

The other issue that the identification strategy needs to accommodate is that some non-participants receive part of the benefits of the program through spillovers. Indirect beneficiaries are firms that do not participate in the program but have some sort of linkage with participants. We are especially interested in those non-treated firms which hired skilled workers or researchers from treated firms, to determine whether labor mobility is the channel for spillovers.

We propose to use the panel structure of our dataset to control for the self-selection of firms in the programs. We control for self-selection in two ways: (i) fixed-effects; and (ii) lagged dependent variables. Each method has its own identification assumptions about the selection of firms into the program. The identification assumption in the first case is that $E(Y0_{it}|x_{it},c_i,T)=E(Y0_{it}|x_{it},c_i)$; that is, conditional on x_{it} and c_i, the potential outcome without program is independent of T. In the second one, the identification assumption is $E(Y0_{it}|x_{it},y_{it-1},\ldots, y_{it-p,}T)=E(Y0_{it}|x_{it}, y_{it-1},,\ldots, y_{it-p,})$; that is, conditional on x_{it} and p-order lags of y_{it}, the potential outcome without program is independent of T.

In the first method, the estimating equation is

$$y_{it}= \delta T_{it} + \gamma x_{it} + c_i + v_{it} \quad (1)$$

[11] CNAE (*ClassificaçãoNacional de AtividadesEconômicas*) is the Brazilian sectoral classification, and it is comparable to the SIC (Standard Industrial Classification).
[12] Sector*State combinations for each kind of treatment are available under request.

where y_{it} is the outcome variable, T_{it} is the treatment variable, x_{it} is a set of control variables, c_i is an unobserved fixed effect possible correlated with T_{it} and x_{it}, and v_{it} is an error term.

In the second method the estimating equation is

$$y_{it} = \rho\, y_{it-1} + \ldots + \rho y_{it-p} + \delta\, T_{it} + \gamma x_{it} + v_{it} \qquad (2)$$

where the variables are the same as those defined above. According to Angrist and Pischke (2009), fixed effects estimates of (1) and random effects estimates of (2) provide upper and lower limits of the true impact, respectively.

The set of control variables in both equations, x_{it}, includes the following:

- Total employees (lpo):–the total number of employees in a given year, in the log form. Source: RAIS.
- Age of firm (lage and lage^2): the log of age of the firm, in quadratic form;
- Export dummy (dexp): a dummy variable that indicates whether or not a firm exported. Source: RAIS.
- Real wages (lsalrel): the log of real average wages of the firm. Wages were deflated according to the IPCA from IBGE (the Brazilian Institute of Geography and Statistics). The IPCA is the Brazilian inflation target official price index. Source: RAIS.
- Sector wages (lsectorwage): the log of real average wages of the firm's 2-digit sector. Including this variable in wage equations allow us to take into consideration the sector-relative variations in wages paid by firms. These sector wages were also deflated accordingly. Source: RAIS.
- Share of workers with first degree (prop_pgrau) and secondary degree (prop_sgrau): proxies for the structure of the labor force by level of schooling in PoTec equations. Source: RAIS.
- Average years of schooling of labor force (lescol): the log of the average years of schooling of the labor force, as a proxy for human capital. This control is used only in productivity equations. Source: RAIS.
- Imports of capital goods (limpbk): the log of capital goods imports, as a proxy for capital. It is used only in productivity equations, and only for the "direct

support" impact models, due to data availability (limpbk is only available until 2007). Source: SECEX.

- Year dummies.
- Regional dummies: there are five regions in Brazil.
- Sector dummies: in this case, four sector dummies were used, based on the OECD classification of technological intensity.

To mitigate endogeneity, we include these variables lagged by one year. Control sets for the combinations of treatment/outcome variables are summarized in Table 14.

Table 14. Summary of Control Variables for Econometric Models

Outcome variable	Innovation support	Time span	Set of controls
PoTec models	Direct support	2000-2010 (direct beneficiaries), 2002-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, prop_pgrau, prop_sgrau, year, region and sector dummies*
	Subvention	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, prop_pgrau, prop_sgrau, year, region and sector dummies*
	Lei do Bem	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, prop_pgrau, prop_sgrau, year, region and sector dummies*
Export models	Direct support	2000-2010 (direct beneficiaries), 2002-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, year, region and sector dummies*
	Subvention	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, year, region and sector dummies*
	Lei do Bem	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lsalrel, year, region and sector dummies*
Size Models	Direct support	2000-2010 (direct beneficiaries), 2002-2010 (indirect beneficiaries)	*Lpo, lage, lage^2,lescol, ldexp, year, region and sector dummies*
	Subvention*	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2,lescol, ldexp, year, region and sector dummies*
	Lei do Bem	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2,lescol, ldexp, year, region and sector dummies*

Source: Authors' compilation.

3. Empirical Results

3.1 Summary Tables

The econometric results are summarized in Tables 16 onwards.[13] For each variable, there are two econometric modeling strategies: a static model estimated through fixed effects and a dynamic model estimated using the random effects estimator. For each of these strategies, there are three possible specifications, which have i) only treatment dummies, with year, region, and sector dummies; ii) treatment dummies with lage and lage^2 (age of firm variables), besides year, region, and sector dummies; and iii) all of the controls mentioned in Table 14.

The most important are the estimates with all controls and the dynamic ones (for level variables). Estimates of types i) and ii) are for comparison purposes, because year, region, sector dummies, and firms are the best exogenous controls available in the databases.

Each model takes into account two types of treatment dummies. The first one measures the average effect of participating into a PDP or receiving some benefit of the PDP through labor mobility spillovers. This treatment dummy is defined as 1 the year a firm receives that treatment and remains as 1 in the subsequent years. The second type of treatment dummies "track" firms in the year in which they receive the treatment and in subsequent years. For example, if a panel allows firm tracking up to three years after receiving the treatment, then there are four treatment dummies: one indicating if this firm is in the year it receives the treatment, the second indicating if the firm is 1 year after receiving the treatment, and so forth. In this case, these four dummies are put in the same econometric model. This second strategy allows the researcher to assess which year an effect peak occurs (if any), or for how long an (supposedly positive) effect may persist.

Coefficients are accompanied by the familiar "*" signs, where *** indicates the coefficient is significant at a 1, ** a 5, and * a 10 percent level of significance, respectively.

3.2 Impact of Innovation Support on Direct Beneficiaries

This section presents the results of estimations that compare direct beneficiaries of the programs against a control group of non-beneficiaries.

[13] Table 15 shows treatment dummy coefficients and their significances only. Full models, which generated these coefficients, are available on request.

3.2.1 Impact of ADTEN, FNDCT, Credits, and Cooperative Projects

The first set programsincludes ADTEN, FNDCT, credit (*reembolsável*) and cooperative projects (*interveniente*). This set has the longest time span for our panel estimates, ranging from 2000 to 2010.

Table 15 summarizes the results of these forms of direct support on innovative effort, measured by PoTec. Fixed effects estimates indicate that direct support increases the probability of hiring PoTec workers and also the number of these workers. According to the fixed effects estimates with controls, receiving one of these innovation programs increases the number of PoTec workers by 11.2 percent[14] on average. Peak effects seem to happen between the second and the fourth year after receiving the program. However, no significant effect was found with respect to the share of PoTec workers to total.

Additionally, dynamic random effects estimates indicate that the number of PoTec workers grows by 4.74 percent due to ADTEN, FNDCT, credit or cooperative projects. In this case, peak effects seem to occur in the year that firms receive the support and two years after. Again, the effects of the programs on the share of PoTec workers were not robust.

As a matter of comparison, Araújo et al. (2009) found a 6.82 percent difference-in-difference in PoTec one year after between treated and control groups, after a PSM application to assess the impact of Sectoral Funds on PoTec, firm size, and high-tech exports (in US$ thousands). Subsequent results were 11.52 percent in the second year, 15.72 percent in the third year, and 26.74 percent in the fourth year. Although these results are not directly comparable,[15] they have something in common, especially the rising effect which lasts up to four years after a firm receives innovation support.

The programs also affect beneficiary size, as measured by total employment. The lower and upper bounds, according to FE with controls and AR(1) RE with controls are 3.3 and 11.3 percent. In both estimates, peak effects seem to appear between the second and the fourth year after receiving the program. For a comparison, see Castillo et al. (2013) on the effect of innovation support programs on employment.

[14] This number is different from the coefficient of the model because the dummy variable needs a transformation ($\exp(b) - 1$) to represent the elasticity.

[15] Estimates are not directly comparable because the time span is a bit different, there were no cuts for sector*state combinations of beneficiaries, the econometric technique is different and, most important, estimates in Araújo et al. (2009) are in diff-in-diff.

Regarding exports, these direct support innovation programs seem to affect the exports variables in general, as shown in Table 16. In the case of the export dummy, the controlled estimate for the linear probability has a significant average effect of 0.108. Year-effect dummies indicate that this positive effect lasts up to five years after the firm receives the support. As expected, in the case of exports per employee, controlled fixed effects estimates show a higher average coefficient than the dynamic random effects. Both average coefficients are significant.

Table 15. Summary of ADTEN, FNCDT, Credit or Cooperative Projects' Impacts on Direct Beneficiaries: Innovative Effort and Firm Size

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after	Effect 7 years after	Effect 8 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	0.116***	0.0930***	0.0932**	0.169***	0.163***	0.159***	0.155***	0.0518	0.0699	0.137
			with age	0.119***	-	-	-	-	-	-	-	-	-
			with controls	0.0746**	0.0474	0.0585	0.129***	0.112**	0.116**	0.114*	0.0185	0.0368	0.0823
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.157**	0.131**	0.182**	0.253***	0.261***	0.248***	0.177	0.0528	0.166	0.249*
			with age	0.175***	-	-	-	-	-	-	-	-	-
			with controls	0.107*	0.0666	0.138**	0.202***	0.200***	0.217***	0.154	0.0743	0.174	0.231*
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0693***	0.092**	0.0653	0.129***	0.0911**	0.057	-0.02006	-0.0729	0.0246	0.1995**
			with age	0.0655***	0.089**	0.0618	0.125***	0.087**	0.054	-0.0235	-0.0769	0.0159	0.1906**
			with controls	0.0464**	0.0858**	0.0411	0.0872***	0.042	0.0376	-0.0491	-0.1017	-0.0053	0.1689*
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	0.0939	0.131**	0.182**	0.253***	0.261***	0.248***	0.177	0.0528	0.166	0.249*
			with age	0.110*	-	-	-	-	-	-	-	-	-
			with controls	0.0605	0.0666	0.138**	0.202***	0.200***	0.217***	0.154	0.0743	0.174	0.231*
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.037*	0.0331	0.0459	0.1051***	0.027	0.011	0.0047	-0.1162**	0.0425	0.164
			with age	0.0398*	0.035	0.0482	0.107***	0.03	0.0147	0.0081	-0.1128**	0.0466	0.1684
			with controls	0.0223	0.138**	0.0867	0.148**	0.161**	0.106*	0.0142	-0.0689	0.0124	0.134

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 years after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after	Effect 7 years after	Effect 8 years after
Employment	Log Linear	Fixed Effects	only dummies	0.0773**	0.0808**	0.0793*	0.0809*	0.0904*	0.0122	-0.0552	-0.1321	-0.0555	0.0293
			with age	0.1299***	0.1136***	0.1217***	0.1468***	0.1623***	0.1039*	0.0666	0.0038	0.1591*	0.2866**
			with controls	0.1073***	0.0825**	0.1041***	0.1299***	0.1455***	0.0895	0.0596	0.0036	0.181*	0.2896**
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0406***	0.025	0.0463***	0.0571***	0.0679***	0.0196	0.0094	-0.0057	0.0376	0.0735**
			with age	0.0404***	0.0252	0.0457***	0.0566***	0.0678***	0.01930	0.01	-0.005	0.0374	0.073**
			with controls	0.0332***	0.0192	0.0386**	0.0494***	0.0596***	0.0106	0.0019	-0.0124	0.0338	0.0645**

Source: Authors' compilation.

Table 16. Summary of ADTEN, FNCDT, Credit, or Cooperative Projects' Impacts on Direct Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after	Effect 7 years after	Effect 8 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0875***	0.0894***	0.103***	0.0961***	0.0822**	0.0928**	0.0547	-0.0302	-0.0180	0.0534
			with age	0.0936***	-	-	-	-	-	-	-	-	-
			with controls*	0.108***	0.0942***	0.121***	0.120***	0.114***	0.127***	0.0965*	0.0205	0.0465	0.118
Export/ Employee	Log Linear	Fixed Effects	only dummies	0.504***	0.610***	0.596***	0.513**	0.426*	0.353	0.162	-0.0908	0.212	1.203**
			with age	0.575***	-	-	-	-	-	-	-	-	-
			with controls*	0.473***	0.6486***	0.5385***	0.4856**	0.4039	0.3415	0.1464	-0.0437	0.2168	1.165**
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.4365***	0.6535***	0.3883***	0.3883*	0.4165**	0.3824**	0.323	0.074	0.4405	1.244***
			with age	0.4064***	0.6306***	0.3614***	0.3176*	0.3873**	0.3553**	0.2904	0.0362	0.3715	1.169***
			with controls*	0.256***	0.4775***	0.2179**	0.1561	0.2228	0.2029	0.1166	-0.1056	0.2494	1.051**

Source: Authors' compilation.

3.2.2. Subvention

The second program under analysis and its impacts on direct beneficiaries is subvention. The panel ranges from 2006 to 2010.

Table 17 shows that subvention does not have a robust impact on the innovative effort of its direct beneficiaries. All controlled fixed effects estimates—linear probability, log of PoTec, and share of PoTec—are non-significant. In turn, the dynamic random effects estimate indicates that subvention may foster a 6.5 percent increase on PoTec of direct beneficiaries with 10 percent significance. They also tend to increase the share of PoTec to total workers. In both cases, the peak effect seems to occur one year after receiving the program. In the case of firm size, none of estimates provided significant results.

These non-robust results may be understood in the context of the study by Morais (2009) of the institutional characteristics of the subvention program. Subvention, a new instrument in the Brazilian innovation support tradition, has undergone some changes in its support design since its release. Another possible explanation is that subvention is targeted at small firms. As can be seen in Table 4, the average size of the grant only surpassed US$1 million in 2008, and small firms may choose not to invest in formal R&D as an innovation input.

Table 17. Summary of the Impacts of Subvention on Direct Beneficiaries: Innovative Effort and Firm Size

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	0.124***	0.0871**	0.140**	0.182***	0.105	0.0372
			with age	0.126***	-	-	-	-	-
			with controls	0.0502	0.0231	0.0895	0.0821	0.0169	-0.0528
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.130	0.0244	0.181**	0.213**	0.156	-0.0236
			with age	0.126	-	-	-	-	-
			with controls	0.0121	-0.0942	0.0971	0.0734	0.0149	-0.132
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0417	-0.083	0.192***	0.067	0.055	-0.115
			with age	0.0435	-0.0819	0.194***	0.069	0.057	-0.116
			with controls	0.0502*	-0.0769	0.196***	0.0899	0.0544	-0.115

Table 17., continued

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	0.138	0.0159	0.218*	0.266**	0.0848	-0.0578
			with age	0.135	-	-	-	-	-
			with controls	-0.00372	-0.110	0.137	0.0643	-0.0894	-0.215*
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.129***	-0.0036	0.2907***	0.154*	0.122*	0.011
			with age	0.129***	-0.0045	0.2902***	0.1539*	0.1539	0.012
			with controls	0.100**	-0.0340	0.263***	0.130	0.0857	-0.0257
Employment	Log Linear	Fixed Effects	only dummies	0.0260	0.0229	0.0255	0.0284	-0.0016	-0.1657
			with age	0.0089	0.0007	0.0061	0.0183	0.0074	-0.1169
			with controls	-0.0273	-0.0289	-0.0313	-0.0125	-0.0209	-0.1492
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	-0.0144	-0.0454	-0.0098	0.0243	-0.0211	-0.0746
			with age	-0.0136	-0.0437	-0.0098	0.0254	-0.02007	-0.0753
			with controls	-0.0224	-0.0521	-0.0189	0.0159	-0.0283	-0.0828

Source: Authors' compilation.

As in the case of ADTEN, FNDCT, credits, and cooperative projects, some impacts from subvention are reported for the export/employee variable, but there are no impacts of subvention on the probability of exporting.

Export/employee models are run only for exporters. Positive impacts of subvention on export intensity come from the fixed effects estimates, and there are no significant impacts from dynamic random effects.

Table 18. Summary of the Impacts of Subvention on Direct Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0391	0.0315	0.0662*	0.0362	0.0432	-0.0434
			with age	0.0411	-	-	-	-	-
			with controls	0.0216	0.0176	0.0489	0.0177	0.0174	-0.0553
Export/ Employee	Log Linear	Fixed Effects	only dummies	0.914***	1.093**	0.904**	0.964**	0.785**	0.395
			with age	0.859***	-	-	-	-	-
			with controls	0.847**	1.054**	0.838**	0.876**	0.672*	0.387
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.238	0.5416	0.091	0.176	0.226	0.035
			with age	0.244	0.546	0.0901	0.188	0.237	0.043
			with controls	0.162	0.464	0.0006	0.115	0.146	-0.0307

Source: Authors' compilation.

3.2.3 Lei do Bem

The final program analyzed is the *Lei do Bem* (tax incentives) program. The panel ranges from 2006 to 2010 but, as distinct from subvention, there are beneficiaries in 2009 and 2010.

The *Lei do Bem* program has had a positive impact on the probability of hiring a PoTec worker. Coefficients range from 0.0266 (controlled fixed effects estimates) to 0.0442 (only dummies). Most of the effect seems to occur in the first year.

With respect to the number of the PoTec workers, *Lei do Bem* has also had a positive and robust effect. Estimates range from 0.0678 (controlled fixed effects) to 0.117 (only dummies, also fixed effects). Comparing controlled fixed effects with AR(1) random effects, *Lei do Bem* increases PoTec by practically the same amount: 7.0 percent in the first case and 7.2 percent in the second case.

Regarding the share of PoTec, there are conflicting signs. All fixed effects estimates have negative signs, the dynamic random effects estimates have a positive sign, and all of the coefficients are significant. Further investigation is needed on this point.

Kannebley Jr. and Porto (2011) report a similar effect of *Lei do Bem* on PoTec, using fixed effects tobit estimates. Although their estimates are not directly comparable to those found in this study, these authors report an average effect of 7-11 percent on beneficiaries.

Size also seems to be affected by *Lei do Bem*. On average, firms grow between 5.7 percent and 8.5 percent after receiving the incentive. In the case of fixed effects with controls, the positive effect vanishes in the third year after benefiting from tax incentives for innovation, and in the case of AR(1) models, in the second year after.

Table 19. Summary of *Lei do Bem* Impacts on Direct Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	0.0442***	0.0499***	0.0477**	0.0358*	0.0182	0.0143
			with age	0.0480***	-	-	-	-	-
			with controls	0.0266*	0.0311**	0.0311	0.0167	0.00256	0.00854
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.117***	0.126***	0.118***	0.0894**	0.119*	0.135
			with age	0.142***	-	-	-	-	-
			with controls	0.0678***	0.0830***	0.0647**	0.0259	0.0693	0.120
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.1075***	0.139***	0.0801***	0.0796***	0.1225**	0.077
			with age	0.106***	0.138***	0.079***	0.078***	0.1203**	0.0751
			with controls	0.0699***	0.104***	0.0443**	0.0403	0.0752	0.0346
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	-0.0622***	-0.0311	-0.0673***	-0.108***	-0.116***	-0.124*
			with age	-0.0413**	-	-	-	-	-
			with controls	-0.0456**	-0.0195	-0.0533**	-0.0898***	-0.0752*	-0.0693
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.028**	0.0516***	0.0048	0.0131	0.0318	0.0196
			with age	0.0333***	0.056***	0.0095	0.0186	0.0381	0.0249
			with controls	0.0244**	0.0467***	0.000840	0.0108	0.0301	0.00630
Employment	Log Linear	Fixed Effects	only dummies	0.0504**	0.0526***	0.0672**	0.0295	-0.0603	0.0148
			with age	0.1051***	0.0947***	0.1235***	0.1141***	0.0573	0.1409*
			with controls	0.0846***	0.0762***	0.1016***	0.088**	0.0425	0.123
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0704***	0.0615***	0.0996***	0.0492*	0.0427	0.163***
			with age	.00703***	0.0609***	0.0992***	0.0491*	0.0435	0.165***
			with controls	0.0555***	0.0474***	0.0848***	0.0329	0.0276	0.1494**

Source: Authors' compilation.

Lei do Bem seems to affect level of exports, but not export status. In terms of probability, controlled fixed effects estimates are not significant, but positive and significant coefficients appear for the only dummies and dummies plus age equations. One possible explanation for the non-robustness is the fact that most (more than 80 percent) *Lei do Bem* beneficiaries are already exporters, so the instrument will do little to change the export status.

When the dependent variable is export/employee, there is a robust positive impact of *Lei do Bem*. Controlled fixed effects and dynamic random effects are, respectively, 0.137 and 0.573, so the dynamic effect AR(1)is higher than the controlled fixed effect. This point needs more research, because the difference between the coefficients is quite high. In any case, *Lei do Bem*

seems to increase the value of exports of firms that are already exporting, but it does not affect the probability of becoming an exporter.

Table 20. Summary of *Lei do Bem* Impacts on Direct Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0253**	0.0245*	0.0254*	0.0188	0.0334	0.0794*
			with age	0.0327***					
			with controls	0.00872	0.0116	0.00533	-0.00167	0.0199	0.0584
Export/ Employee	Log Linear	Fixed Effects	only dummies	0.209**	0.227**	0.220**	0.210	0.0614	0.111
			with age	0.324***					
			with controls	0.137*	0.158*	0.128	0.134	0.0608	0.0695
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.478***	0.437***	0.511***	0.509***	0.427**	0.733***
			with age	0.438***	0.402***	0.471***	0.463***	0.375*	0.6902***
			with controls	0.573***	0.225***	0.271***	0.241**	0.127	0.479***

Source: Authors' compilation.

a. Impact of Innovation Support on Indirect Beneficiaries

This section presents the results of estimations comparing indirect—or spillover—beneficiaries of the programs with a control group of non-beneficiaries.

i. Impact of ADTEN, FNDCT, Credits, and Cooperative Projects

Table 21 below shows the impacts of ADTEN, FNDCT, credits, and cooperative projects on the measures of innovative effort from indirect (or spillover) beneficiaries. The time span for this analysis (and also for indirect impacts of these programs on productivity) is 2002-2010.

There seems to be a positive although not robust impact of these direct support programs on innovative effort. In the first set of equations—linear probability of hiring PoTec (other than the workers who define the spillover effect)—the average effect is only significant in dummies only and dummies plus age estimates, but not in the controlled fixed effects estimate. Regarding the log of PoTec workers, all estimates are significant and robust, indicating that ADTEN, FNDCT, credits, and cooperative projects may foster innovative effort through labor mobility spillovers. The estimated elasticity of these programs on indirect beneficiaries is 14.4 percent, according to the controlled fixed effects estimate, and 19.3 percent according to the AR(1) random effects. The positive effect seems to last up to four years after hiring a PoTec worker

from a direct beneficiary firm. With respect to the share of PoTec workers, the dynamic random effects model showed a positive impact, and the fixed effects model had a negative but only 10 percent significant impact.

It may seem counterintuitive that spillover effects are higher than direct effects, and this is the case not only for ADTEN, FNDCT, credit, and cooperative project results but for subvention and *Lei do Bem* as well. However, the results are not strictly comparable because they are related to different control groups.

Total employment is also affected indirectly by labor mobility of workers from ADTEN, FNDCT, credit, or cooperative project beneficiaries. As in the case of PoTec, lower and upper bounds for the average impact—7.4 and 28.9 percent, respectively—are higher than those for direct beneficiaries.

Regarding exports, there is robust evidence that ADTEN, FNDCT, credit, and cooperative projects positively affect both the probability of exporting and the export intensity, that is, exports/employee through the labor mobility channel. In the latter case, as can be seen in Table 23, controlled fixed effects and AR(1) random effects average coefficients are 0.32 and 0.168, respectively.

Table 21. Summary of ADTEN, FNDCT, Credit, or Cooperative Projects' Impacts on Indirect (or Spillover) Beneficiaries: Innovative Effort and Firm Size

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	0.0399**	-0.0164	0.0815***	0.1024***	0.0951***	0.0528**	-0.021	0.0125
			with age	0.0436**	-0.0135	0.0855***	0.1066***	0.1005***	0.061***	-0.0144	0.0225*
			with controls	0.00035	-0.0441**	0.034*	0.0465**	0.0377**	0.0057	-0.045	-0.011
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.238***	0.1094**	0.3441***	0.3533***	0.3902***	0.4101***	0.3045*	0.3142*
			with age	0.2526***	0.1205***	0.3573***	0.3667***	0.4142***	0.4507***	0.3378*	0.3616**
			with controls	0.1351***	0.0147	0.2291***	0.2262***	0.2531***	0.2879***	0.2131	0.2239*
	Log Linear with Dynamics	Random Effects	only dummies	0.2063***	0.1034***	0.3894***	0.1738***	0.1759***	0.2103***	0.2131	0.1707**
			with age	0.208***	0.1054***	0.3906***	0.1758***	0.1788***	0.2126***	0.222*	0.1768**
			with controls	0.177***	0.0742*	0.3541***	0.1472***	0.1536***	0.183***	0.2257*	0.1737*
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	-0.0244	-0.106***	0.0758*	0.0637	0.0025	-0.0481	-0.1857	-0.2204
			with age	-0.0119	-0.097***	0.0883**	0.075*	0.0224	-0.0136	-0.1581	-0.1802
			with controls	-0.0493*	-0.132***	0.0404	0.027	-0.017	-0.0478	-0.1264	-0.1215
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0922***	-0.0039	0.2396***	0.1129***	0.0598**	0.0747**	0.1243	0.1382**
			with age	0.0937***	-0.0025	0.2412***	0.1143***	0.0615**	0.0766**	0.1253	0.1399**
			with controls	0.0739***	-0.0183	0.2148***	0.0897***	0.0501*	0.0555	0.1219	0.127*
Employment	Log Linear	Fixed Effects	only dummies	0.2701***	0.2367***	0.275***	0.2984***	0.3777***	0.3228***	0.3101**	0.3649**
			with age	0.3121***	0.2714***	0.307***	0.3367***	0.4568***	0.4513***	0.4199***	0.516***
			with controls	0.2544***	0.2219***	0.2449***	0.2611***	0.3749***	0.3858***	0.3516***	0.4276***
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.079***	0.0931***	0.0569***	0.0719***	0.0974***	0.0751***	0.0651**	0.0177
			with age	0.0785***	0.093***	0.0571***	0.0708***	0.0965***	0.0731***	0.0628**	0.0163
			with controls	0.0712***	0.0163***	0.0496***	0.0613***	0.0889***	0.0653***	0.0548**	0.0012

Source: Authors' compilation.

Table 22. Summary of ADTEN, FNDCT, Credit, or Cooperative Projects' Impacts on Indirect (or Spillover) Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0779***	0.0557***	0.0875***	0.102***	0.112***	0.105**	0.0426	-0.00645
			with age	0.0833***	0.0599***	0.0929***	0.108***	0.120***	0.118**	0.0540	0.0085
			with controls*	0.0519***	0.0355**	0.0588**	0.0633**	0.0719**	0.0809	0.0105	-0.0459
Export/Employee	Log Linear	Fixed Effects	only dummies	0.415***	0.191*	0.266**	0.779***	0.686***	1.082***	-0.0958	0.807
			with age	0.401***	0.190*	0.338***	0.780***	0.661***	0.558*	0.0366	0.126
			with controls*	0.320***	0.178*	0.151	0.651***	0.547**	0.955***	-0.304	0.533
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.180***	0.150**	0.156**	0.337***	0.118	0.232	0.304	-0.389
			with age	0.168***	0.141**	0.144*	0.319***	0.104	0.214	0.293	-0.397
			with controls*	0.168*	0 .0871	0 .0846	0.251**	0.0283	0.133	0.201	-0.491

Source: Authors' compilation.

3.3.2 Impact of Subvention

Subvention has some impact on innovative effort of indirect beneficiaries, as can be seen in Table 23. Indeed, the only non-significant impacts are the fixed effects coefficients for the share of PoTec workers to total. Regarding the number of PoTec workers, subvention increases on average the number of these workers from 3.6 percent (controlled fixed effects) to 15.4 percent (AR(1) Random effects). The panel for these and subsequent models ranges from 2008-2010.

In contrasting the spillover with the direct results, it is important to remember that indirect beneficiaries of subvention programs are large firms. One hypothesis to explain this result is that small firms may not engage informal R&D to innovate, but larger firms do.

Subvention also seems to have positive impacts on firm size. Firms appear to grow between 5.9 percent and 19.2 percent on average after hiring a PoTec from a subvention beneficiary firm, and this effect seems to last for two years in the fixed effects estimates. In the case of AR(P) RE estimates, the effect seems to be limited to the year that the PoTec worker arrives.

Table 23. Summary of Subvention Impacts on Indirect (or Spillover) Beneficiaries: Innovative Effort and Firm Size

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	-0.0016	-0.0539	0.0597	0.0244
			with age	-0.00047	-0.0534	0.0609	0.0275
			with controls	-0.0114	-0.0602*	0.0488	0.0125
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.103*	0.00955	0.194***	0.180**
			with age	0.103**	0.0081	0.192***	0.187**
			with controls	0.0357*	-0.0441	0.108*	0.115
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.185***	0.0240	0.320***	0.100
			with age	0.189***	0.0252	0.324***	0.106
			with controls	0.154***	-0.0038	0.285***	0.0724
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	-0.117***	-0.203***	-0.0344	-0.0486
			with age	-0.118***	-0.204***	-0.0365	-0.0448
			with controls	-0.122***	-0.200***	-0.0416	-0.0599
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0611**	-0.174**	0.205***	0.0308
			with age	0.0637**	-0.169**	0.206***	0.0332
			with controls	0.103***	-0.131	0.247***	0.0727

Table 23., continued

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect1year after	Effect 2 years after
Employment	Log Linear	Fixed Effects	only dummies	0.1841***	0.2176***	0.173***	0.1164**
			with age	0.181***	0.2124***	0.1646***	0.1286**
			with controls	0.1762***	0.2015***	0 159***	0.1385**
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0647***	0.1608***	0 .0227	0.0485*
			with age	0.0651***	0.1599***	0.0238	0.0486*
			with controls	0.0575***	0.1583***	0.0145	0.0383

Source: Authors' compilation.

The indirect impacts of subvention on exports are not robust in Table 24, in the sense that they only appear on dummies and dummies plus age fixed effects models for the probability of exporting. The model with controls is not significant. In the case of export intensity, the subvention instrument was insignificant in all models.

Table 24. Summary of Subvention Impacts on Indirect (or Spillover) Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0379	0.0348	0.0174	0.0853*
			with age	0.0397*	0.0356	0.0193	0.0898*
			with controls	0.0231	0.0249	-0.0027	0.0658
Export/ Employee	Log Linear	Fixed Effects	only dummies	0.325**	0.193	0.316*	0.656***
			with age	0.0333	-0.108	0.0218	0.390*
			with controls	0.172	0.0595	0.152	0.478*
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.493***	0.328**	0.552***	0.659***
			with age	0.478***	0.312**	0.536***	0.643***
			with controls	0.233**	0.0982	0.277	0.373**

Source: Authors' compilation.

3.3.3 Impact of Lei do Bem

The *Lei do Bem* tax incentives program was implemented in 2006. Therefore, the panel for *Lei doBem* indirect impacts ranges from 2008 to 2010.

The *Lei do Bem* does not have robust impacts on innovative effort, as can be seen in Table 25. AR(1) Random effects estimates indicate a positive indirect impact of 6.3 percent on average. In this case, the average positive impact comes from the significant positive impact in

the second year. However, controlled RE were not significant. Moreover, the probability of hiring other PoTec workers is negatively influenced by the arrival of PoTec workers from *Lei do Bem* beneficiary firms.

Fixed effects estimates for the share of PoTec workers show a negative sign (AR(P) RE are not significant), but this can be explained by taking into account that the indirect impact of *Lei do Bem* is robust with respect to firm size, and it is higher than the impact of *Lei do Bem* on PoTec. Indeed, the number of *Lei do Bem* indirect beneficiaries grows on average between 8.36 percent (AR(P) RE) and 16.1 percent (FE). Positive effects on size persist at least up to one year after hiring PoTec workers from direct beneficiary firms.

Table 25. Summary of *Lei do Bem* Impacts on Indirect (or Spillover) Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 years after	Effect 2 years after
PoTec in binary form	Linear Probability	Fixed Effects	only dummies	-0.0181	-0.0405***	0.0264	0.0536*
			with age	-0.0169	-0.0396***	0.0281*	0.0551**
			with controls	-0.0417***	-0.0606***	-0.00468	0.0168
Log(PoTec)	Log Linear	Fixed Effects	only dummies	0.0233	-0.0124	0.102**	0.0837
			with age	0.0277	-0.00908	0.110***	0.0860
			with controls	-0.0276	-0.0580***	0.0398	0.0209
	Log Linear with Dynamics	Random Effects	only dummies	0.0890***	0.0147	0.226***	0.0956**
			with age	0.0900***	0.0157	0.227***	0.0979**
			with controls	0.0613***	-0.0107	0.194***	0.0690
Share of PoTec/Total Employees	Log Linear	Fixed Effects	only dummies	-0.123***	-0.154***	-0.0547**	-0.0741**
			with age	-0.119***	-0.150***	-0.0487**	-0.0699*
			with controls	-0.129***	-0.154***	-0.0739***	-0.0913***
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	-0.00152	-0.0651***	0.114***	0.0274
			with age	0.0046	-0.0597***	0.122***	0.0356
			with controls	0.0249	-0.0412**	0.145***	0.0656*

Table 25., continued

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after
Size	Log Linear	Fixed Effects	only dummies	0.1638***	0.1722***	0.1545***	0.1035**
			with age	0.1816***	0.187***	0.1796***	0.1229**
			with controls	0.1496***	0.1543***	0.1492***	0.0932**
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.0918***	0.1118***	0.0712***	0.028
			with age	0.0925***	0.112***	0.0722***	0.0298
			with controls	0.0803***	0.1005***	0.0589***	0.0166

Source: Authors' compilation.

As in the case of direct beneficiaries, *Lei do Bem* seems to affect export intensity but not the probability of becoming an exporter. Again, this may be due to the fact that 76 percent of indirect beneficiaries of *Lei do Bem* are already exporters.

Table 26. Summary of *Lei do Bem* Impacts on Indirect (or Spillover) Beneficiaries: Exports

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after
Export dummy	Linear Probability	Fixed Effects	only dummies	0.0139	0.0145	0.0165	-0.0064
			with age	0.0157	0.0159	0.01930	-0.0043
			with controls	0.00256	0.00326	0.0058	-0.0218
Export /Employee	Log Linear	Fixed Effects	only dummies	0.4721***	0.382***	0.681***	0.590***
			with age	0.327***	0.233***	0.529***	0.528**
			with controls	0.394***	0.334***	0.542***	0.435**
	Log Linear with Dynamics	AR(1) Random Effects	only dummies	0.369***	0.328***	0.465***	0.354**
			with age	0.339***	0.303***	0.427***	0.427**
			with controls	0.161***	0.140**	0.227***	0.0835

Source: Authors' compilation.

3.3.4 Impacts by Size

In order to assess variation in impacts according to the size of the beneficiary firms—both direct and indirect (spillover) ones—Table 27 and successive tables depict the average effect of the programs under analysis on innovation efforts, interacted with three categories of firm size: up to 100, between 100 and 500, and more than 500 employees. All results point in the same direction: when they occur, large firms drive the positive average impacts in the previous tables. The

interaction between treatment variables (both direct and indirect) with the "more than 500 employees" firm size class is always positive and significant. In contrast, the interaction with the "up to 100 employees" size class is only significant when it is *negative*—that is, the indirect impacts of the *Lei do Bem.* The interaction between treatment variables and the middle size class is not always significant, but whenever it is significant, it is positive and lower than the coefficient of the "more than 500 employees" interaction. The only exception to this is the negative sign in the indirect impacts of *Lei do Bem* equations.

These results indicate that all programs tend to foster innovation efforts in larger firms more effectively than in small firms, either through the direct support or the mobility channel. There are two possible explanations for this: small firms may innovate using other inputs than formal R&D, or these impacts only reflect the concentration of innovation—both inputs and outputs—in large firms.

Table 27. Summary of ADTEN, FNCDT, Credit, or Cooperative Projects' Impacts on Direct Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	-0.0163	0.077	0.4149***
			with age	-0.0107	0.0914	0.4442***
			with controls	-0.0001	0.0569	0.3703***
	Log Linear with Dynamics	Random Effects	only dummies	-0.0382	0.0552**	0.2624***
			with age	-0.039	0.0502*	0.2554***
			with controls	-0.0293	0.0007	0.2044***

Source: Authors' compilation.

Table 28. Summary of Subvention Impacts on Direct Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	0.013	0.209*	0.7726***
			with age	0.0122	0.204*	0.7261***
			with controls	-0.0152	0.1665	0.5107***
	Log Linear with Dynamics	Random Effects	only dummies	0.0295	0.0637	0.1757***
			with age	0.033	0.0642	0.1686***
			with controls	0.0601	0.0478	0.1317*

Source: Authors' compilation.

Table 29. Summary of *Lei do Bem* Impacts on Direct Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	-0.0428	0.0141	0.0908**
			with age	-0.0516	0.0355	0.1189***
			with controls	-0.0182	0.0004	0.078**
	Log Linear with Dynamics	Random Effects	only dummies	-0.0082	0.0832***	0.1998***
			with age	-0.0079	0.0822***	0.1965***
			with controls	-0.0282	0.0388	0.1449***

Source: Authors' compilation.

Table 30. Summary of ADTEN, FNDCT, Credit, or Cooperative Projects' Impacts on Indirect (or Spillover) Beneficiaries: Innovative Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	0.0164	0.1932***	0.3175***
			with age	0.0069	0.1969***	0.3439***
			with controls	-0.0464	0.0706	0.2167***
	Log Linear with Dynamics	Random Effects	only dummies	-0.0134	0.1379***	0.301***
			with age	-0.007	0.1405***	0.3016***
			with controls	-0.0197	0.1053***	0.2706***

Source: Authors' compilation.

Table 31. Summary of Subvention Impacts on Indirect (or spillover) Beneficiaries: Innovation Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	-0.183*	0.07	0.2523**
			with age	-0.1984**	0.0651	0.2636
			with controls	-0.1318	-0.0473	0.185**
	Log Linear with Dynamics	Random Effects	only dummies	0.0244	0.1329***	0.3064***
			with age	0.028	0.1336***	0.3141***
			with controls	0.0196	0.0877*	0.2772***

Source: Authors' compilation.

Table 32. Summary of *Lei do Bem* Impacts on Indirect (or Spillover) Beneficiaries: Innovation Effort

Variable	Model	Method	Specification	Up to 100 employees	From 100 to 500 employees	More than 500 employees
Log(PoTec)	Log Linear	OLS Fixed Effects	only dummies	-0.1206***	-0.0497*	0.1742***
			with age	-0.1402***	-0.0431	0.1854***
			with controls	-0.1765***	-0.0965***	0.1166***
	Log Linear with Dynamics	Random Effects	only dummies	-0.1366***	0.0337	0.2644***
			with age	-0.1336***	0.0341	0.2654***
			with controls	-0.143***	-0.0042	0.2406***

Source: Authors' compilation.

4. Final Remarks

This paper attempted to measure both direct and indirect impacts of innovation support measures in Brazil. Indirect impacts are supposed to occur through the labor mobility channel. Mobility is defined as the movement of workers in technical-scientific occupations. Technical-scientific occupations are defined as in Araújo et al. (2009). Hence, by tracking mobility, this study measures both direct and indirect impacts, taking advantage of the potential of the Brazilian databases.

Outcome variables were technical-scientific workers (PoTec), representing innovation efforts; export performance, measured in binary form and also as exports/employee; and firm size, measured by total employees other than PoTec workers. The impacts of innovation support on productivity (proxied by real wages) appear in the Appendix.

Results on the direct impact of innovation support measures are in line with previous studies. It was found that ADTEN, FNDCT, credits, and cooperative projects foster PoTec between 4.74 and 11.2 percent, in controlled estimates (AR(1) RE and FE, respectively). This is comparable to the results of Araújo et al. (2009). In turn, the average impact of *Lei do Bem* tax incentives is 7 percent in controlled estimates on PoTec. These results are similar to those of Kannebley Jr. and Porto (2011), using different techniques.

Taking into account all specifications that deal with direct beneficiaries, we found that innovation support in the form of ADTEN, FNDCT, credits, or cooperative projects seems to have the greatest impact on fostering innovation. In fact, the probability of hiring PoTec workers

is more impacted by this kind of support than by *Lei do Bem*. The same is true for the number of these workers, although the difference is quite small on the average of the three specifications.

Subvention did not seem to have important impacts on innovative effort (as far as PoTec is concerned) of direct beneficiaries. This may be may be related to the small average size of beneficiaries and to the fact that the program, launched in 2006, is still relatively new to ADTEN, FNDCT, credits, and cooperative projects. Thus, our panel may be too recent to show any effect of the program.

Hence, with the exception of the subvention program, this paper suggests that direct support in the form of credit or cooperative projects fosters more innovative effort than tax incentives. However, in this study, innovative effort is proxied by PoTec workers, and direct and tax-based incentives for innovation have different purposes. Sound innovation support relies on both kinds of support.

Regarding firm size (proxied by the number of employees), results basically replicate what happens to PoTec. ADTEN, FNDCT, credits, and cooperative projects foster higher size growth than *Lei do Bem*, and subvention does not have a robust impact on the size variable.

Exports also seem more affected by ADTEN, FNDCT, credits, and cooperative projects than by *Lei do Bem*. Indeed, *Lei do Bem* does not significantly impact the probability of exporting, probably due to the fact that most of *Lei do Bem* direct beneficiaries are already exporters, and the export level is less affected by tax incentives than by ADTEN, FNDCT, credits, and cooperative projects. Again, subvention did not affect the probability of exporting, and the impact of subvention on the export level is not always significant.

Indirect (or spillover) results for PoTec were similar to the direct results. Notwithstanding, the magnitude of the coefficients was higher. Further investigation is needed on this point, but since the control groups are not strictly comparable, neither are the results. Neither innovation support program affected the probability of hiring PoTec. However, the number of PoTec seems to be more affected by ADTEN, FNDCT, credits, and cooperative projects than by other instruments. Indeed, the indirect impacts of *Lei do Bem* on the number of PoTec are not robust. When it comes to indirect (or spillover) impacts, subvention was shown to foster innovative effort through the labor mobility channel, taking into account that indirect beneficiaries of subvention are basically large firms. In any case, the indirect impacts of subvention are lower than those of ADTEN, FNDCT, credits, and cooperative projects.

All of the programs indirectly affect size through the mobility channel, and the ones with the greatest impact are, again, ADTEN, FNDCT, credits, and cooperative projects.

Regarding exports, ADTEN, FNDCT, credits, and cooperative projects and *Lei do Bem* positively affect the export level. Subvention affects the export level only in AR(1) models. Contrary to direct impacts on beneficiaries, higher impacts on the export level are fostered by *Lei do Bem.* With respect to the probability of a firm's becoming an exporter, only ADTEN, FNDCT, credits, and cooperative projects have a positive indirect effect.

When firm size is considered in order to assess the extent to which firm size influences positive impacts of the programs, some interesting results emerge. First, firms with more than 500 employees always increase their innovation efforts due to the innovation support, either directly or indirectly. The opposite is true of firms up to 100 employees. Innovation programs have not been shown to foster innovation efforts either directly or indirectly. This may have important policy implications, especially because small firms often lose their PoTec workers to large ones.

It can be argued that small firms innovate using inputs other than formal R&D, or that these results only reflect the concentration of innovation—both inputs and outputs—in large firms in Brazil. In any case, innovation support targeted at small firms (e.g. subvention) needs to be better understood. This study showed that such support tends to have little impact on direct beneficiaries, although it may have some positive overall impact through the labor mobility channel towards large firms.

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Appendix

Wage Models

Outcome variable	Innovation support	Time span	Set of controls
Productivity models	Direct support	2000-2010 (direct beneficiaries), 2002-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lescol, limpbk, lsectorwage, year, region and sector dummies*
	Subvention	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lescol, lsectorwage, year, region and sector dummies*
	Lei do Bem	2006-2010 (direct beneficiaries), 2008-2010 (indirect beneficiaries)	*Lpo, lage, lage^2, lescol, lsectorwage, year, region and sector dummies*

Source: Authors' compilation.

Table A.1. Summary of ADTEN, FNCDT, Credit or Cooperative Projects' Impacts on Direct Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after	Effect 7 years after	Effect 8 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0258**	-0.0189**	-0.0175*	-0.0211*	-0.0383***	-0.032*	-0.163*	-0.106**	-0.107***	-0.142***
			with age	-0.0103	-0.0088	-0.0051	-0.0021	-0.0168	-0.0048	-0.1293	-0.0678	-0.0532*	-0.0765**
			with controls	-0.012	-0.0088	-0.00542	-0.0048	-0.0186	-0.0056	-0.1296	-0.0656	-0.0504	-0.0783**
	Log Linear with Dynamics	Random Effects	only dummies	0.0206***	0.0197***	0.031***	0.031***	0.0171**	0.026**	-0.072	0.018	0.024	0.018
			with age	0.0165***	0.0165**	0.0281***	0.0271***	0.0128	0.022**	-0.0779	0.012	0.0153	0.0093
			with controls	-0.0242	-0.0132	-0.0092	-0.0132	-0.0158	0.013	-0.454	-0.0073	-0.0187	-
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0094*	-0.0094*	-0.0126	-0.0177*	-0.0419***	-0.049***	-0.162*	-0.1723*	-0.1842*	-0.1985**
			with age	-0.006	-0.006	-0.0062	-0.007	-0.027**	-0.0293*	-0.1367	-0.1402	-0.1443	-0.1509
			with controls	0.0004	0.0004	-0.0018	-0.0082	-0.0154	0.0112	0.0193	0.032	0.0289	-

Source: Authors' compilation.

Table A.2. Summary of Subvention Impacts on Direct Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	0.00587	-0.00318	0.00275	0.0156	-0.00137	-0.00581
			with age	0.00696	-0.00350	0.00385	0.0184	0.00396	0.00404
			with controls	0.00162	-0.00624	-0.00085	0.0127	-0.0016	0.0008
	Log Linear with Dynamics	Random Effects	only dummies	0.0280***	0.0261	0.0227	0.0398**	0.0317*	0.00075
			with age	0.0282***	0.0266	0.0226	0.0402**	0.0319*	0.00063
			with controls	-	-	-	-	-	-
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.00713	-0.0071	-0.0040	0.0040	0 .0019	-0.0319
			with age	-0.00594	-0.0071	-0.0040	0 .0079	0 .0019	-0.0319
			with controls	-0.0161	-0.0163	0.0768*	-	-	-

Source: Authors' compilation.

Table A.3. Summary of *Lei do Bem* Impacts on Direct Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0375***	-0.02***	-0.0477***	-0.0699***	-0.0892***	-0.093***
			with age	-0.0292***	-0.0133*	-0.0393***	-0.0578***	-0.0726***	-0.0733**
			with controls	-0.0264***	-0.0105	-0.0366***	-0.0558***	-0.0677***	-0.0666*
	Log Linear with Dynamics	Random Effects	only dummies	0.0313***	0.0345***	0.0271***	0.0223***	0.0397***	0.0815**
			with age	0.0298***	0.0332***	0.0255***	0.0204***	0.0374***	0.0794**
			with controls	-	-	-	-	-	-
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0167***	-0.0167***	-0.0381***	-0.0664***	-0.0787***	-0.0452
			with age	-0.0127***	-0.0128***	-0.0312***	-0.0554***	-0.0632***	-0.0257
			with controls	-0.0116	-0.0117	-0.022	-	-	-

Source: Authors' compilation.

Table A.4. Summary of ADTEN, FNDCT, Credit or Cooperative Projects' Impacts on Indirect (or Spillover) Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 year after	Effect 2 years after	Effect 3 years after	Effect 4 years after	Effect 5 years after	Effect 6 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0341***	-0.0128	-0.0251*	-0.0609***	-0.0621***	-0.0819***	-0.0041	-0.0892**
			with age	-0.0177	-0.0004	-0.0089	-0.0426**	-0.0376*	-0.0452*	0.029	-0.0443
			with controls*	0.0036	0.008	0.0048	-0.015	0.0058	0.0079	0.0433	-
	Log Linear with Dynamics	Random Effects	only dummies	0.0359***	0.0374***	0.0369***	0.0217**	0.0414***	0.0428***	0.1035***	0.0862***
			with age	0.0321***	0.0338***	0.0332***	0.018*	0.0373***	0.0374***	0.0997***	0.0803***
			with controls*	0.0095*	0.0138**	0.0106	-0.0061	0.0109	0.0106	0.0752**	0.0494**
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0151***	-0.009	-0.0234**	-0.0618***	-0.068***	-0.0823***	-0.049	-0.0469
			with age	-0.0123***	-0.0075	-0.0199*	-0.0546***	-0.055***	-0.0625***	-0.0238	-0.0146
			with controls*	-0.0124***	-0.0041	-0.0179*	-0.0545***	-0.057***	-0.0668***	-0.0282	-0.021

Source: Authors' compilation.

Table A.5. Summary of Subvention Impacts on Indirect (or Spillover) Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 years after	Effect 2 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0336	-0.0236*	-0.0384**	-0.0522**
			with age	-0.0310	-0.02240	-0.0357*	-0.0453**
			with controls	-	-	-	-
	Log Linear with Dynamics	Random Effects	only dummies	0.0205***	0.0126	0 .0225**	0.0322**
			with age	0.0195**	0.0118	0.0213**	0.0314**
			with controls	0.00012	-0.00583	0.00053	0.0109
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0146**	-0.0182*	-0.0279*	-0.0436*
			with age	-0.0130**	0.0173*	-0.0253*	-0.0382**
			with controls	-0.0153**	-0.0217*	-0.0333**	-0.0439**

Source: Authors' compilation.

Table A.6. Summary of *Lei do Bem* Impacts on Indirect (or Spillover) Beneficiaries: Productivity

Variable	Model	Method	Specification	Average effect	Effect in the year	Effect 1 years after	Effect 2 years after
Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0146*	-0.0057	-0.0328***	-0.0403
			with age	-0.0109	-0.0027	-0.0276**	-0.0352
			with controls	-0.0212***	-0.0128***	-0.0371***	-0.0491***
	Log Linear with Dynamics	Random Effects	only dummies	0.026***	0.03***	0.0197***	0.0158
			with age	0.0248***	0.029***	0.0184***	0.0139
			with controls	0.0093**	0.0146***	0.0012	-0.004
1st diff of Log (Real Wages)	Log Linear	OLS Fixed Effects	only dummies	-0.0068	-0.0069	-0.0371***	-0.0588***
			with age	-0.0057	-0.0058	-0.0338***	-0.0537***
			with controls	-0.0088**	-0.0089**	-0.03***	-0.0503***

Source: Authors' compilation.