

How Does Public Support Influence Firms' Innovativeness? An Analysis Based on the 2022 Semiannual PINTEC Innovation Survey

Frederico Rocha (Institute of Economics – UFRJ)
fred@ie.ufrj.br

Marcia Rapini (Cedeplar – UFMG)
msrapini@cedeplar.ufmg.br

Marina Szapiro (Institute of Economics – UFRJ)
marina@ie.ufrj.br

João Carlos Ferraz (Institute of Economics – UFRJ)
jcferraz@ie.ufrj.br

Abstract

The relevance of public support for business innovation is relatively consensual in economic literature. However, there remains a significant gap in the availability of evidence and analyses regarding the relative importance of the different instruments available, despite persistent debates among authors about the appropriateness of one type of instrument over another. Some advocate for a narrow set of instruments, such as tax incentives, while others defend the use of a broader range, including financing and non-repayable grants. This article aims to contribute to this discussion through the analysis of quantitative evidence. Its objective is to assess the impact of public support instruments on the innovativeness of Brazilian industrial firms by estimating the increased probability of introducing product innovations for the international and national markets. For this purpose, data from the 2022 Semiannual PINTEC, representative of Brazilian industrial firms with more than 100 employees, were combined with data from the 2022 Annual Industrial Survey (PIA). Matching techniques and econometric models indicate a strong association between firms that received some type of public support and an increased likelihood of innovating for the global market. The results show that public support instruments are a key driver of innovation among Brazilian companies. However, their impact varies according to the degree of innovativeness—whether the innovation targets the global or the domestic market. Direct intervention instruments appear more effective in fostering radical product innovations aimed at the global market, whereas indirect intervention instruments seem better suited to incremental innovations or adaptations geared toward the domestic market.

Keywords

Innovation policy; Innovativeness; Policy instruments; Semiannual PINTEC

Introduction: The Relevance of Public Support for Innovation through a Wide Variety of Policy Instruments

Two distinct perspectives typically underpin innovation policies. On the one hand, some analysts argue that policies should aim to correct market failures. On the other hand, there are those who advocate that government intervention should be directed to build knowledge networks. The first perspective focuses on addressing market imperfections, such as uncertainty or the difficulty of appropriating returns from innovation. These imperfections may lead to suboptimal levels of innovative effort from a social standpoint. Recommended policies in this view include intellectual property rights legislation and market price corrections. Additionally, resources may be allocated to financing R&D activities, creating financial mechanisms and institutions such as venture capital funds, offering tax incentives, and providing non-repayable funds (Arrow, 1962; Hall and Lerner, 2010).

The second perspective emphasizes the systemic nature of innovation activities and highlights the importance of structuring innovation networks. From this viewpoint, innovation is characterized by knowledge flows among actors who possess different—and, crucially, complementary—competencies. Firms and other actors within supply chains, networks, or innovation systems control different fragments of the knowledge necessary for innovation. Mechanisms that facilitate these information flows between agents are a central component of the innovation process. Consequently, suppliers, clients, universities, research laboratories, and governmental institutions are part of an interactive network that enables innovation. Innovation, therefore, is a collective achievement.

Adopting this network-based view of innovation has important analytical implications. First, the linear model is insufficient to fully capture the complexity of the innovation process, as supply-side factors represent only part of the challenge. Second, there is a necessary emphasis on studying relationships among actors. The way actors within innovation networks interact is critical and varies across countries, regions (Cassiolato, Lastres, and Maciel, 2003), and sectors (Malerba and Nelson, 2011). Lastly, the institutional framework and infrastructure in which the system or network operates play a crucial role in shaping innovative behavior. Strengthening innovative activity may require both improving existing relationships and establishing new connections.

In general, innovation policies rely on a mix of instruments with different characteristics and objectives, designed to stimulate firms to increase their investments in innovation activities. These policies offer financial and non-financial support to help firms mitigate the inherent uncertainties of the innovation process (Bittencourt and Rauen, 2021).

Because of the importance given to networks, scholars and policymakers have increased their interest in studying policy mixes and the effectiveness of specific mixes of instruments. OECD (2024) has surveyed the literature on the effectiveness of policy mixes and particular instruments for OECD countries. They have found that indirect intervention instruments such as R&D tax credits and subsidies tend to perform well, and, on the contrary, targeted direct interventions such as grants and subsidies have performed poorly. They also find that complementary policies that improve access to inputs may foster

innovation. In Brazil, there are several studies that argue for the benefits of indirect intervention mechanisms on R&D and technological efforts and lower benefits for direct intervention mechanisms (Kannebley and Porto 2012, Kannebley, Shimada and De Negri 2016, ABDI 2013). However, Rocha (2024) finds the opposite effect when isolating private expenditure, that is, whenever one excludes the fiscal benefits to R&D expenditures offered by law. from R&D total expenditures

The objective of this paper is to assess the impact of public support instruments on firms' innovativeness, measured as the increased probability of introducing product innovations for either the global or domestic markets. To this goal, we use data from the 2022 Semiannual PINTEC, with a focus on firms' use of government support for innovation activities.

Following this introduction, the paper is organized into four additional sections. The next section presents the theoretical framework, focusing on the relationship between innovation policies, types of intervention—whether direct or indirect—and their expected outcomes for firms' innovation activities. Section three details the methodology and the variables used in the analysis. Section four discusses the results of the econometric estimations. Finally, section five offers the paper's conclusions.

Innovation Policy and Support Instruments: A Brief Review of Brazil's Recent Experience

Innovation policy instruments can generally be classified into two categories: those that operate on the supply side and those that act on the demand side. Supply-side instruments aim to stimulate firms to increase their investments in innovation by reducing the costs associated with innovative activities. Examples of supply-side instruments include:

- Subsidies, tax incentives, and direct grants to companies, such as R&D subsidies;
- Loans with subsidized interest rates;
- Equity acquisition in nascent innovative companies;
- Incentives for public university research and for expanding cooperation between academia and the private sector;
- Research grants and public support for training firm personnel (Bittencourt and Rauen, 2021).

Demand-side instruments, in turn, are designed to induce firms to invest more in innovation by ensuring demand growth, establishing requirements for products and services, or increasing user participation in the innovation process (Edler, 2013). Examples include regulation (such as mandatory R&D), public procurement for innovation, and pre-commercial procurement contracts.

In the Brazilian context, three key milestones transformed the government's capacity to implement innovation policies. The first was the creation of sectoral funds in the late 1990s and early 2000s, which provided the necessary financial resources to support innovation policy. The second milestone was the enactment of the **Innovation Law in 2004**, which

enabled and regulated a new set of policy instruments, including the provision of direct subsidies to firms. The third was the “**Lei do Bem**” (**Law of Good Practices**), enacted in 2005, which consolidated and expanded tax incentives for innovation.

Following these legislative changes, new instruments were created, and a larger volume of resources was allocated to innovation policies, particularly between 2006 and 2014. During this period, innovation policies successfully encouraged firms to expand their innovative activities.

In the subsequent period, from 2015 to 2022, successive governments with more liberal economic orientations significantly reduced the scope of direct intervention instruments, either by discontinuing them or by withholding resources from associated funds. In contrast, indirect intervention instruments were largely maintained. According to TCU (2021), discretionary expenditures by the Ministry of Science, Technology, and Innovation (MCTI) fell from a peak of BRL 8.4 billion in 2014 to BRL 3.2 billion (current prices) in 2020. Similarly, disbursements from the National Fund for Scientific and Technological Development (FNDCT) declined from BRL 3.7 billion to BRL 0.9 billion over the same period. Meanwhile, tax expenditures increased from BRL 7 billion to BRL 10 billion, with most of these resources allocated to the Lei do Bem and the Lei de Informática (the latter capturing the largest share).

In summary, during the first decade of the 21st century, Brazil both increased the volume and diversified the range of instruments available to support innovation (De Negri, 2023). The impacts and effectiveness of these instruments have been analyzed in several studies. Rocha (2019), for example, examined the effects of public procurement policies for innovation on private R&D spending using data from the 2014 PINTEC and found positive effects, particularly among smaller firms, firms in lower-tech sectors, and when the procurement policy was applied in isolation rather than in conjunction with other instruments.

The *Lei do Bem* (Good Law) is probably the most studied instrument of Brazilian innovation policy. Initial findings, such as those by ABDI (2013) and Kannebley and Porto (2012), indicated that the instrument was highly effective, based on RAIS data and analyses of its influence on the hiring of workers in technical and scientific occupations (PoTec). These results remained robust even when observations with zero values in the dependent variable were excluded. However, this evidence appears to contrast with findings from more recent models. The study by Colombo (2017) clarifies this apparent contradiction by using R&D expenditures reported in PINTEC as the dependent variable, finding that the additional spending induced by the *Lei do Bem* is lower than the average amount of the associated tax incentive, suggesting an incomplete crowding-out effect. This impression is confirmed by Rocha (2024) that uses data from PINTEC from 2003, 2005, 2008, 2011 and 2014 editions. The conclusion states that direct instruments have positive effect on private R&D expenditures and Lei do Bem, though positive, show feebler effects.

Colombo and Cruz (2018), analyzing data from the 2008 and 2011 editions of PINTEC, also found positive effects of tax incentives on R&D expenditures, with an average increase of R\$ 1.1 million, in addition to a rise in the hiring of researchers with university degrees.

Regarding the *Lei de Informática* (Informatics Law), although it establishes R&D counterparts, its effects on technological efforts are more limited, given its design is more oriented toward the development of the technology manufacturing sector than directly toward innovation. ABDI (2013) concluded that only the subsidy provided by FINEP and the tax benefits under the Lei do Bem yielded positive results, with the latter showing the strongest effect. These findings are in line with studies such as those by Kannebley and Porto (2012).

Rocha (2024) notes that firms that benefitted from various instruments exhibited higher private R&D spending intensity than their counterparts, even when different methods were applied to control for selection bias. In contrast, his findings suggest that direct intervention instruments generally have a positive impact on private R&D intensity—even when using a stricter indicator such as private R&D spending—compared to ABDI’s use of employment in scientific and technical occupations (PoTec). Furthermore, the subsidies associated with the Lei do Bem appear to have a more uncertain impact, especially when we exclude firms with zero R&D expenditure from the sample. Meanwhile, direct intervention instruments such as R&D funding, economic subsidies, and research scholarships demonstrated positive impacts both on the likelihood of conducting R&D and on its intensity. The effectiveness of these instruments appears to be strongly linked to their targeted nature, which requires the undertaking of future activities as a condition for accessing benefits.

In the field of demand-side instruments, Rocha (2019) analyzed the effects of public procurement for innovation, using data from the 2014 PINTEC, and identified positive effects, particularly for smaller companies, firms in low-technology sectors, and when the instrument was used in isolation.

Additionally, studies such as those by Machado, Martini, and Gama (2017) showed that credit granted by BNDES increased R&D activities among beneficiary firms by at least 30%, based on PINTEC data from 2003 to 2014. Rauen, Saavedra, and Hamatsu (2019) also confirmed that direct credit from FINEP led to a 76% average increase in the hiring of scientific and technical personnel in firms with more than ten employees that already had prior technological efforts.

Considering this panorama, analyzing the impacts of innovation policies proves essential for guiding adjustments, particularly in designing more effective instruments that better align with the specific characteristics of the Brazilian innovation system. The most recent data from the 2022 Semiannual PINTEC offer an unprecedented opportunity to understand the effects of these instruments in the most recent period, characterized by fiscal challenges and shifts in the role of the state in supporting innovation.

Public Support for Innovation and the Structural Characteristics of Industrial Firms

This section presents the methodology employed in this study. The impact of innovation policy instruments is evaluated by examining their effect on firms’ innovativeness. The analysis is based on data from the 2022 Semiannual PINTEC, conducted by the Brazilian

Institute of Geography and Statistics (IBGE) in partnership with the Brazilian Industrial Development Agency (ABDI) and the Federal University of Rio de Janeiro (UFRJ). This research project, which spans 50 months, consists of seven survey cycles, with two conducted each year. Its objective is to generate indicators related to innovation and associated themes, thereby supporting the design, implementation, and monitoring of public policies and business strategies.

The seven survey cycles focus on basic innovation indicators (including innovation activities and R&D) as well as related topics. The survey covers Brazilian industrial firms with 100 or more employees operating in the extractive and manufacturing industries. The total population includes approximately 9,600 firms, from which a sample of 1,500 to 1,600 companies is drawn. According to the 2022 Annual Industrial Survey (PIA), this set of firms accounts for:

- 84.4% of total industrial value added (IVA),
- 86.1% of total net sales revenue, and
- 62.9% of total employment in Brazil's extractive and manufacturing industries in 2021.

Nevertheless, in terms of the absolute number of firms, this group represents only **2.8%** of all industrial companies in the country for the same year.

Measuring Innovativeness: New Products for International and National Markets

The 2022 Semiannual PINTEC adopts the 4th edition of the Oslo Manual, which introduces the concept of business process innovation, unlike previous editions of the PINTEC (2005, 2008, 2011, 2014, and 2017), which were based on the 3rd edition and classified innovation into product, process, organizational, and marketing categories. The new definition has significant methodological implications for survey design and data analysis.

Given the accumulated knowledge on product innovation, this study focuses exclusively on firms that introduced product innovations, as this approach captures a well-documented dimension of innovativeness. The choice is also supported by empirical evidence, such as the study by De Negri, Salerno, and Castro (2005), which demonstrates that product-innovating firms exhibit distinctive characteristics compared to non-innovators.

To measure the degree of innovativeness, we use firms' responses to Question 4 of the 2022 Semiannual PINTEC, which asks whether the products introduced by the company represented novelty for the firm itself, for the national market, or for the global market.

We assess the influence of government support on two types of innovation outcomes:

1. Innovation for the global market, representing higher novelty and radical innovation.
2. Innovation for the national market, associated with lower levels of novelty—such as incremental improvements, adaptations, or imitative innovations.

Accordingly, we estimate two equations:

- In the first, the dependent variable equals 1 if the innovation is new to the global market, and 0 otherwise.
- In the second, the dependent variable equals 1 if the innovation is new to the national market, and 0 otherwise.

This distinction enables us to evaluate how different policy instruments influence varying degrees of novelty in innovation. Differentiating between direct and indirect intervention instruments allows a more precise understanding of which types of instruments are effective for different scopes of innovation.

Innovation Policy Instruments

The 2022 Semiannual PINTEC identifies seven categories of public support instruments:

1. Tax incentives under the Lei do Bem (Law of Good Practices);
2. Tax incentives under the Lei de Informática (Information Technology Law);
3. Non-refundable grants and subsidies;
4. Financing for R&D, with or without partnerships with universities and research centers;
5. Financing for the acquisition of machinery and equipment (M&E);
6. Public procurement programs for innovation;
7. Other types of support.

The distribution of these instruments among innovative firms, disaggregated by firm size, is presented in Table 1.

Table 1 Percentage of Innovating Firms, per Size and Usage of Innovation Instruments

Innovation Policy Instruments	% of Innovative Firms	% of Firms with 100 to 249 Employees	% of Firms 250-499 Employees	% of Firms with 500 or more Employees
Tax incentives under the Lei do Bem (Law of Good Practices)	26,2%	31,0%	26,8%	42,3%
Tax incentives under the Lei de Informática (Information Technology Law)	6,3%	47,1%	18,2%	34,7%
Non-refundable grants and subsidies	4,0%	43,5%	9,8%	46,9%
Financing for R&D, with or without partnerships with universities and research centers	8,4%	34,5%	19,6%	45,8%
Financing for the acquisition of machinery and equipment (M&E)	13,5%	50,2%	23,6%	26,2%
Public procurement programs for innovation	2,5%	68,6%	7,7%	23,7%

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Tax incentives—namely those under the Lei do Bem and the Lei de Informática—are classified as indirect intervention instruments, which are subject to self-selection by firms. In contrast, the other instruments involve formal selection processes based on public calls or administrative evaluation, involving varying degrees of selectivity by government agencies.

Firms With and Without Public Support: Addressing Selection Bias

Selection bias is a major concern in evaluating innovation policies, that may occur either because government agencies may prefer to fund firms that are already innovative and likely to succeed, reducing the risk of failure or, conversely, firms with good characteristics may be more inclined to seek public support, resulting in a bias where better-performing firms appear more likely to benefit from policies. This may result in governmental provision of support to activities that would have happened even without its intervention. Ideally, public support should be directed toward activities that would not occur in the absence of government intervention, providing complementarity rather than substitution for private resources (Wallsten, 2000).

In this context, tax incentives (Lei do Bem and Lei de Informática) are particularly prone to the second type of bias (firm self-selection), whereas instruments like public procurement, grants, R&D financing, and machinery financing are more vulnerable to the first type (government selection of already successful firms).

Various statistical methods exist to address selection bias, including panel data techniques, difference-in-differences models, and first-difference estimators. However, these approaches require data over multiple time periods, which are not available in the current dataset.

For this reason, we adopt a matching technique, specifically Coarsened Exact Matching (CEM), to create a control group with characteristics similar to those of treated firms (i.e., those that received public support). This approach is particularly suited when continuous variables make it difficult to find exact matches, as it groups firms into intervals (e.g., by size categories rather than exact employment numbers).

Firms are classified as “treated” if they reported receiving at least one of the seven types of public support. The control group comprises firms that reported receiving none of the support instruments.

The variables used for matching include:

- Firm size category, based on PINTEC: under 100, 100–249, 250–499, and 500+ employees.
- Two-digit industry classification (CNAE).
- Ownership type, coded as 1 for foreign-owned (if more than 50% foreign capital) and 0 for domestic firms.
- A productivity proxy based on average wages from the PIA:
 - 1 = wages below (mean – standard deviation);
 - 2 = between (mean – standard deviation) and mean;
 - 3 = between mean and (mean + standard deviation);
 - 4 = above (mean + standard deviation).

The matching procedure significantly reduced differences in means, medians, and standard deviations between the treatment and control groups, ensuring a balanced comparison. Detailed distributions by size, ownership, wage band, and industry are reported in Tables 2 to 5.

Table 2 – Distribution of Firms by Size Cohort, pre and post Matching

Size	Pre-Matching		Post-Matching	
	No Support	With Support	No Support	With Support
Até 99	33	3	14	3
100 a 249	370	85	158	70
250 a 499	136	64	62	55
500 or more	390	436	206	312
Total	929	588	440	440

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Table 3 – Distribution of Firms by Nationality

Nationality	Pre-Matching		Post-Matching	
	No Support	With Support	No Support	With Support
Domestic	776	397	339	339
Multinational	153	191	101	101
Total	929	588	440	440

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Table 4 – Distribution of Firms by Wage Level

Wage Cohort	Pre-Matching		Post-Matching	
	No Support	With Support	No Support	With Support
1	5	0		
2	707	301	286	286
3	157	199	115	115
4	60	88	39	39
Total	929	588	440	440

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Table 5 – Distribution of Firms by Sector (ISIC)

ISIC	Pre-Matching		Post-Matching	
	No Support	With Support	No Support	With Support
10	101	59	58	58
11	15	12	11	11
12	12	5	3	3
13	60	14	14	14
14	69	15	15	15
15	45	11	11	11
16	37	10	10	10
17	38	14	11	11
18	22	6	4	4
19	37	15	13	13
20	33	49	27	27
21	18	25	13	13
22	44	37	35	35
23	40	31	22	22
24	23	31	18	18
25	50	33	25	25
26	16	29	15	15
27	35	27	18	18
28	44	45	31	31
29	37	45	31	31
30	16	12	5	5
31	39	24	22	22
32	33	15	11	11
33	42	4	4	4
Extrativa	23	20	13	13
Total	929	588	440	440

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Is Public Support Related to the Innovativeness of Brazilian Industrial Firms?

In 2022, only 2.6% of the 9,584 Brazilian industrial firms with more than 100 employees introduced new products to the world market, while 12.5% have introduced product innovations that are new to the market (see table 6). This shows that the majority of firms that innovate by product in Brazil do it at the firm level.

Table 6 – Number of Industrial Firms by Innovation Level, Brazil, 2022

	Number of Firms	% of total firms
Number of firms	9584	100
Did not innovate in product	5053	52.7
Introduced Product Innovation	4531	47.3
Novelty to world market	251	2.6
Novelty to domestic market	1196	12.5
Novelty to firm	3084	32.2

Source: Own elaboration using Semiannual PINTEC Database, 2022.

Table 7 uses the matched sample to test the effects of each independent variable on the probability that a firm is innovative at the global level. Equation (1) includes the following independent variables:

i)

- (i) $\ln(EMP)$, the natural logarithm of the number of employees, based on the 2022 PIA;
- (ii) *Capital origin*, which equals 1 for multinational firms, and 0 otherwise;
- (iii) Two average wage dummies: *PROD 3*, which equals 1 for firms whose average wages are above the overall mean but less than one standard deviation above it (0 otherwise); and *PROD 4*, which equals 1 for firms whose average wages are at least one standard deviation above the mean (0 otherwise);
- (iv) *COOP*, which equals 1 if the firm cooperates with another entity in the national innovation system; and
- (v) *Support*, which equals 1 if the firm received government support through at least one of seven policy instruments, and 0 otherwise.

Items (i) to (iv) refer to intrinsic characteristics of the firm, while the *Support* variable reflects its engagement with innovation policy.

Equation (2) includes the same variables as equation (1), but replaces the general *Support* variable with individual indicators for each of the seven types of support.

Results from equation (1) show that *PROD 4*, the wage dummy, is the most explanatory variable for determining a firm's probability of being innovative at the global level. The coefficient is positive and statistically significant at the 1% level. The average marginal effect indicates an increase of 14.5 percentage points in the probability of being innovative. As a dummy variable, this represents the overall impact on probability. It is expected that better-performing firms paying higher wages are more likely to innovate, partly due to a more qualified workforce (note that *PROD 3* is also positive and significant at the 10% level). Conversely, innovation may also explain higher productivity and, therefore, higher average wages. This suggests the presence of feedback effects. The dataset does not allow for dynamic modeling, limiting conclusions on causality. It is worth noting that higher

wages are generally found in larger firms. However, the regression suggests that even smaller firms may be innovative if their average wages are high.

Next in explanatory power is the *COOP* variable, which is also positive and significant at 1%, with a marginal effect of 6.1 percentage points. A firm's position within the national innovation system and the density of its relationships appear to influence its innovative capacity, in line with systemic models of innovation. Innovation is a complex process that requires interaction among diverse actors in the innovation system.

The government support variable is positive and significant at 5%, increasing the probability of a firm being globally innovative by 3.8 percentage points. Thus, public support positively influences the innovation process.

In equation (2), the analysis turns to the effects of individual instruments. Note that matching was performed only for the overall *Support* variable, not for each instrument. In this equation, the *PROD 4* and *COOP* dummies remain the most explanatory variables for global-level innovation.

Among the instruments, *R&D funding* has a positive and statistically significant coefficient at 1%, with a marginal effect of 4.6 percentage points. These instruments typically involve administrative selection and evaluation, rather than self-selection, and require counterpart investments by firms. These results are consistent with Rocha (2024).

This is followed by the “Other” category, which remains positive and significant at 5%, and the *Lei do Bem*, significant at 10%. The “Other” category lacks detail, so it is unclear what type of support or result it represents. The *Lei do Bem* is characterized by self-selection and retrospective submission of tax benefit claims. It has traditionally shown the best results among instruments, according to various studies (Kannebley, Shimada, and De Negri, 2016).

Conversely, *financing for machinery and equipment* has a negative and significant effect at 5%. This result likely reflects the type of innovation such instruments promote—technological flows originating from firms engaged in R&D in machinery and equipment sectors, which then spread to other industries. Thus, the immediate effect of obtaining such financing is innovation within the firm itself, not necessarily for the external market. This instrument is also dominated by firms with 100 to 249 employees, i.e., relatively smaller firms compared to those benefiting from other instruments. Moreover, this instrument is not intended to foster highly novel innovations, but rather process innovations within the firm.

Table 8 presents the regression results for innovation at the national market level. The purpose here is to contrast this with firms that introduced innovations at the global level, recognizing that innovation at the national level may require a distinct type of innovative effort.

Equation (3) presents results for overall government support, while Equation (4) breaks support down by instrument. As with the global-level regressions, the cooperation variable shows the highest statistical significance and remains positive. Wage dummy variables also

retain explanatory importance. Again, the government support dummy is positive, now significant at the 1% level, with a marginal effect of 12.1%. Although the increase in probability is larger for national-level innovation than for global-level, this statistic should be interpreted with caution given the much lower baseline probability of global-level innovation.

In Equation (4), control variables maintain the same signs and significance as in Equation (3). In contrast to the global innovation model, R&D funding did not increase the probability of becoming innovative in the national market. *Lei de Informática* and *Lei do Bem* are, respectively, the most explanatory and impactful instruments in this context, confirming the strong influence of fiscal incentive instruments. Economic subsidies and non-repayable grants also have positive and significant effects at the 5% level. Other instruments did not significantly affect the probability of innovation in the domestic market.

The comparison between the two levels of innovation suggests that different instruments have distinct impacts and roles within the National Innovation System. Fiscal instruments, due to their continuity over time and association with routine processes, may be more oriented toward incremental innovations. In contrast, instruments such as R&D financing are generally linked to projects that funding agencies identify or verify as truly innovative.

Table 7 – Probit Regressions, Innovation at the Global Market Level as Dependent Variable

Variables	Coefficient	AME	Coefficient	AME
	(1)		(2)	
(Intercept)	-2.7*** (0.429)		-2.3*** (0.459)	
log(EMP)	0.03 (0.063)	0	-0.02 (0.069)	0
Origem_de_capital	-0.07 (0.224)	-0.01	-0.11 (0.236)	-0.01
PROD				
3	0.36* (0.193)	0.029	0.31 (0.204)	0.025
4	0.93*** (0.281)	0.145	0.85*** (0.297)	0.1
COOP	0.67*** (0.183)	0.061	0.65*** (0.19)	0.055
APOIO	0.43** (0.189)	0.038		
LEIDOBEM			0.33* (0.185)	.0.028
LEIINFO			-0.05 (0.296)	-0.004
SUBVENCAO			-0.04 (0.322)	-0.003
FINANCIAMENTO			0.54*** (0.21)	0.046
EQUIP			-0.72** (0.331)	-0.061
COMPRAS			-4.7 (181)	-0.4
OUTROS			0.74** (0.329)	0.062
N	880		880	

Standard error in parenthesis

*Significant at the 10% ** Significant at the 5% ***Significant at the 1% level

Table 8 – Probit Regressions, Innovation at the Domestic Market Level as Dependent Variable

Coeficiente	Equação (3)	Efeito Marginal Médio	Equação (4)	Efeito Marginal Médio
(Intercept)	-2*** (0.262)		-1.8*** (0.271)	
log(EMP)	0.07* (0.039)	0	0.06 (0.041)	0
Origem_de_capital	0.2 (0.143)	0.052	0.19 (0.145)	0.049
PROD 3	0.38*** (0.123)	0.105	0.28** (0.126)	0.075
4	0.6*** (0.201)	0.171	0.52** (0.204)	0.145
COOP	0.73*** (0.109)	0.191	0.76*** (0.111)	0.194
APOIO	0.46*** (0.111)	0.121		
LEIDOBEM			0.39*** (0.112)	0.1
LEIINFO			0.6*** (0.201)	0.154
SUBVENCAO			0.46** (0.221)	0.117
FINANCIAMENTO			-0.18 (0.161)	-0.045
EQUIP			-0.17 (0.161)	-0.044
COMPRAS			-0.2 (0.339)	-0.052
OUTROS			0.22 (0.284)	.0055
N	880		880	

Standard error in parenthesis

*Significativo a 10% ** Significativo a 5% ***Significativo a 1%

Conclusion

Before moving on to a final assessment of the findings, it is necessary to acknowledge some limitations of this study. First, the survey's sampling framework does not allow the extrapolation of results to small firms (those with fewer than 100 employees).

Consequently, the study does not capture the dynamics of small enterprises or startups. Additionally, the analysis is confined to the extractive and manufacturing industries, meaning the results cannot be generalized to other sectors, particularly those relevant to digitalization and artificial intelligence, which are predominantly situated in the services sector. Future research should extend the analysis to these sectors.

Furthermore, while the use of matching techniques reduces selection bias issues, it does not eliminate them entirely. It is possible that the results would differ if more sophisticated approaches—such as panel data methods—were employed. Thus, deeper and more comprehensive studies are recommended for future research.

Nevertheless, the findings of this study yield important implications for public policymakers and business managers. First, the results indicate that public support is effective in fostering innovation, thereby justifying not only the continuation but potentially the expansion of such policies.

Furthermore, the results also suggest that innovation policy instruments are not neutral with respect to the type and level of innovation they influence. The evidence indicates that:

- Direct intervention instruments (e.g., R&D financing, grants) are more effective in fostering radical innovations with novelty at the global level.
- Indirect instruments (e.g., tax incentives) tend to be more effective for incremental innovations, typically aimed at the national market, often involving the adoption or adaptation of technologies already available internationally.

This finding underscores that policy instruments are not substitutes, but rather complementary tools within the National Innovation System (NIS). When coupled with the strong impact observed from collaborative activities—as evidenced by the variable for cooperation—these results highlight the centrality of knowledge flows and the complex web of relationships within innovation systems.

The study also emerges from a context in which resources allocated to direct intervention instruments, such as financing and grants, have been drastically reduced over the past six to eight years. The conclusions drawn here suggest that such reductions may have seriously harmed the performance of the national industrial sector. At the same time, the growing reliance on tax-based instruments seems to have fostered a pattern of industrial development increasingly focused on imitation and incremental innovation, with less emphasis on generating high-novelty products. This lesson should be carefully considered by policymakers when designing the future of Brazil's innovation strategy.

Additionally, the fact that radical innovation depends on instruments that require administrative selection and project evaluation suggests that strengthening the capabilities of public agencies should be a central concern for policymakers. Selecting projects is inherently difficult and subject to risk, but it is a necessary task for the effective functioning of the National Innovation System, and public agencies must be adequately equipped to perform this function competently.

References

- ABDI. (2013). Mensuração e efetividade dos instrumentos de apoio à inovação no Brasil. Fonte: <http://www.abdi.com.br/Estudo/Volume4.pdf>.
- Arrow, K. (1962). Economic Welfare and the Allocation of Resources for Invention. Em NBER, *The Rate and Direction of Inventive Activity: Economic and Social Factors* (pp. 609-626). Princeton: Princeton University Press. Fonte: <http://www.nber.org/chapters/c2144F>.
- Bittencourt, P. F.; Rauen, A.T. (2021) Políticas de inovação: racionalidade, instrumentos e coordenação. In: RAPINI, M. S. et al. (org.). **Economia da Ciência, Tecnologia e Inovação: Fundamentos teóricos e a economia global**. 2. ed. Belo Horizonte: FACE – UFMG,. p. 516–541.
- Cassiolato, J. E., Lastres, H., & Maciel, M. (2003). Systems of Innovation and Development Evidence from Brazil. Cheltenham: Edward Elgar.
- Colombo, D. G.; Cruz, H. N. Impactos da política fiscal de inovação brasileira na composição de investimentos privados e no tipo de inovação. *Revista Brasileira de Inovação*, v. 17, n. 2, p. 377-414, 2018.
- De Negri, F. (2023) Políticas de Inovação para a Produtividade. Em: Silva Filho, E.B.; Oliveira, J., M., Araújo, B.C. P .O. Eficiência produtiva: análise e proposições para aumentar a produtividade no Brasil. Brasília: Ipea.
- Edler, J. (2013) Review of policy measures to stimulate private demand for innovation. Concepts and effects. *Compendium of evidence on the effectiveness of innovation policy intervention*, n. 13/13, p. 44.
- Hall, B. H., & Lerner, J. (2010). The financing of R&D and innovation. *Handbook of the Economics of Innovation*, 1, 609-639.
- Machado, L.; Martini, R. A.; Gama, M. *Does BNDES innovation credit boost firms' R&D expenditures? Evidence from Brazilian panel data*. Rio de Janeiro: BNDES, 2017.

De Negri, J.; Salerno, M. e Castro, A. B. (2005) Inovações, Padrões Tecnológicos e Desempenho das Firms Industriais Brasileiras. Em De Negri e Salerno (ed.) Inovações, Padrões Tecnológicos e Desempenho das Firms Industriais Brasileiras. IPEA, Brasília.

De Negri, J. A., & Koeller, P. (2011). Políticas de incentivo à inovação tecnológica no Brasil. IPEA.

Kannebley, S., Shimada, F., & De Negri, F. (2016). Efetividade da Lei do Bem no Estímulo aos Dispendios de P&D: uma análise com dados de painel. Pesquisa e Planejamento Econômico, 46(3), pp. 111-145. Fonte: <http://ppe.ipea.gov.br/index.php/ppe/article/viewFile/1680/1235>.

Malerba, F., & Nelson, R. (2011). “Learning and Catching Up in Different Sectoral Systems: Evidence from Six Industries. Industrial and Corporate Change, 20(6), pp. 1645-1675. doi:10.1093/icc/dtr062

OECD (2024) are industrial policy instruments effective? A review of the evidence in OECD countries. https://www.oecd.org/en/publications/are-industrial-policy-instruments-effective_57b3dae2-en.html.

Rauen, A.T. Políticas de inovação: racionalidade, instrumentos e coordenação. In: Rapini, M. S. et al. (org.). Economia da Ciência, Tecnologia e Inovação: Fundamentos teóricos e a economia global. 2. ed. Belo Horizonte: FACE - UFMG, 2021. p. 516–541.

Rocha, F. Compras governamentais para inovação aumentam o esforço inovador? Evidências ao caso brasileiro. **Revista Brasileira de Inovação**, Campinas, SP, v. 18, n. 1, p. 37–62, 2019.

Rocha, F. (2024). Avaliando a Política de Inovação no Brasil, 2005-2014. IE_UFRJ, Texto para Discussão 09/2024, https://www.ie.ufrj.br/images/IE/TDS/2024/TD_IE_009_2024_ROCHA%20v2.pdf.