PUBLIC FUNDING, UNIVERSITY-INDUSTRY INTERACTION AND INNOVATION OUTCOME: EMPIRICAL EVIDENCE FOR BRAZILIAN FIRMS

Daniel Pedro Puffal (Unisinos)
Gisele Spricigo (Unisinos)
Janaina Ruffoni (Unisinos)

Resumo:
A inovação tem sido vista como uma fonte para a sobrevivência e expansão de empresas, bem como um elemento importante para explicar o desenvolvimento econômico. Vários aspectos da economia buscam facilitar a inovação, tais como recursos tecnológicos, o capital humano qualificado, interações entre empresas e universidades, um sistema regulatório e ajuda financeira adequada. A relação entre a produção de conhecimento científico e tecnológico desempenha um papel importante para a inovação. Nos países desenvolvidos, é possível identificar a existência de mecanismos de interação entre estas duas dimensões, em que há um fluxo de informação e conhecimento para ambas as áreas de produção. Por outro lado, nos países em desenvolvimento, como o Brasil, essa interação é menos dinâmica, porque há poucas interações entre empresas e universidades. Para intensificar essas relações, o governo busca desempenhar um papel fundamental, fornecendo apoio financeiro para promover a inovação. O objetivo deste artigo é explorar os efeitos de fundos públicos e os tipos de interação universidade-empresa para os seguintes resultados da inovação: de produto e inovação de processo. Além disso, busca-se entender o efeito de moderação de fundos públicos para as relações entre as interações com base em informações técnicas da universidade e interações baseadas em recursos físicos da universidade e resultados da inovação. A amostra é baseada na população de 1.688 empresas brasileiras que tiveram qualquer tipo de interação com universidades e/ou centros de pesquisa. Foi desenvolvida uma pesquisa para coletar dados de gestores das empresas, incluindo tipos de interação, o uso de financiamento e desempenho inovador. A amostra foi constituída por 325 empresas (taxa de resposta de 19,25%). Os modelos de regressão foram utilizados para avaliar o impacto dos fundos públicos, as interações com base em informações técnicas e interações baseadas em recursos físicos, para a inovação de produtos e processos. Além disso, foi testado o efeito de moderação de fundos públicos em moderar as relações diretas de diferentes tipos de interações. Os principais resultados mostram que: as interações universidade-indústria com base no uso do conhecimento da universidade tem uma relação positiva e significativa com a inovação de produtos da empresa, confirmando a primeira hipótese sobre a inovação de produtos; já a aplicação do financiamento público tem relação negativa e significativa com a inovação dos processos das empresas. É importante notar que existem especificidades do contexto brasileiro para explicar os resultados, considerando o financiamento público a inovação, a sua eficácia para a atividade inovadora da empresa e o nível da interação universidade-empresa.

Palavras-chave: inovação, financiamento, interação universidade-empresa.

Abstract:
Innovation has been viewed as a source for survival and expansion of firms as well as an important element to explain economic development. Several aspects of economy facilitate innovation such as technological resources, qualified human labor, interactions among firms and universities, a regulatory system, and proper financial aid. The relationship between scientific knowledge production and technological knowledge production performs an important role for innovation development. In developed countries, it is possible to identify the existence of feedback mechanisms
between these two dimensions, in which there is a flow of information and knowledge for both areas of production. On the other hand, in developing countries, such as Brazil, this interaction is less dynamic because there are few interactions between firms and universities. To intensify such relationships, the government plays a key role by providing financial support to promote innovation. The objective of this paper is to explore the effects of public funds and types of university-industry interaction for the following innovation outcomes: product and process innovation. In addition, it is explore the moderation effect of public funds for the relationships between interactions based on the university’s technical information and interactions based on the university’s physical resources and innovation outcomes. The sample is based on the population of 1.688 Brazilian firms that had any type of interaction with universities and/or research centers. It was developed a survey to collect data from firms’ managers including types of interaction, use of funding and innovative performance. The sample was constituted of 325 firms (19.25% response rate). A regression models were used to evaluate the impact of public funds, interactions based on technical information and interactions based on physical resources, for product and process innovation. In addition, it was tested the moderation effect of public funds in moderating the direct relationships of different kinds of interactions. The principal results show that the university-industry interactions based on the use of the university’s knowledge has a positive and significant relationship with firm’s product innovation, confirming the first hypothesis regarding product innovation. The application of public funding has negative and significant relationship with firm’s process innovation. It is import to note that there are specificities of Brazilian context considering the innovation public funding, its effectiveness for the firm’s innovative activity and the university-business interaction that contributes to explain the results.

Key-words: Innovation, Public funding, University-Industry Interaction

1. Introduction

Innovation has been seen as a source for survival and growth of firms as well as an important element to explain the wealth of regions and nations. Its emergence is facilitated by the existence of various aspects, such as economic infrastructure, skilled human resources, cooperative relationship between universities and industry, appropriate legal frameworks, and funding instruments available. The relationship between scientific and technological knowledge production plays an important role in innovation’s development (Mazzoleni; Nelson, 2007). In developed countries, it is possible to identify the existence of a feedback mechanism between these two dimensions (Cohen, Nelson Walsh, 2002). However, in developing countries, such as Brazil, this flow is less dynamic due to few interactions between universities and industry (Suzigan; Albuquerque, 2011).

The government plays an important role in the interactions between university and industry, providing funding to research projects involving these two actors (Kang; Park, 2012). The effects of public funding for research and development (R&D) have been studied by several authors. There are those who find a positive relationship with regard to private investment in R&D (Levy; Terleckyj, 1983), those who state the purpose of complementarity between public and private investment (Leyden; Link, 1991) and there is also some authors that understands that public funding has a substitution effect in relation to private investment (Carmichael, 1981). In addition, studies have found that these effects can be influenced by the firm’s size, sector, technological intensity, economic environment and among others.

In Brazil, the inclusion of innovation as a priority in public policy is relatively recent. Only in the 1990s the policy for science, technology and innovation becomes relevant. Currently there are several
instruments present in the Brazilian policy and is important to understand what is the relation between these instruments and the innovative activity of firms. Some researches that have been studying the subject, such as Avellar (2009), focus on the analysis between the tax incentives and private spendings, seeking to understand how public incentives stimulate, in fact, innovation. The results are mixed, with some finding the effects of 'sum' and others showing the 'substitution' effect between public incentives and private resources for innovation. Thus the debate on the impact of public funding for innovation in Brazil is intense and more studies on the subject are relevant.

From a database obtained from a Brazilian survey of 325 firms that have a relationship with universities, this work aims to explore the direct effects of the types of university-industry interaction and public funding in generating innovation in products and processes in the firm. Furthermore, we seek to explore the moderating effect of public funding in the various types of relations between universities and industry in generating innovative results in the firms.

The motivation for this paper, on the one hand, is based on a certain consensus that the academic literature shows the need for public stimulus to innovation, taking into account the characteristics of Brazilian encouragement and funding. On the other hand, due to the wide variety of types of interactions presented in the literature, the study aims, in the same time identify whether there is evidence that some kind of interaction generates better results than others, in terms of firm’s innovation.

The paper is divided as follows. Following this introduction, we bring concepts related to the university-industry interaction, and later one, the public funding of innovation in Brazil discussion. In the fourth section, we describe the empirical method in detail, the firm data and variables. The empirical results are in the fifth section and the last section provides final remarks.

2. The university-industry interaction

Universities have been cited as key actors in innovation systems (Nelson, 1993), and research carried out in these facilities have been playing an important role as a source of knowledge and development of new technologies applied to industry. In recognition of this fact, industrialized countries governments hold since 1970 several initiatives to bring universities to industrial innovation activities (Mowery and Sampat, 2007). Many of these initiatives aim to boost local economic development based on university research, taking advantage of the creation of science parks, incubators, support to incubated firm, venture capital availability and other forms of support institutions that provide greater interaction between universities and industrial innovation.

One of the important roles of universities, for development countries, is the advance in the frontiers of knowledge concerning applicability in the productive sector. Universities are general sources of knowledge required for basic research activities (Nelson, 1990), as well as sources of expertise related to technology applied in enterprises (KLEVORICK et al, 1995), besides being responsible for the formation and training of scientists and engineers able to solve problems related to the innovative process of firms (Rosenberg and Nelson, 1994). Another important contribution of universities to the innovation process is the generation of new technology-based firms in the university environment (spin-offs) (Stankiewicz, 1994).

Klevorick et al. (1995) present empirical evidence on the role of universities and science as an important source of technological opportunities for industrial innovation, moreover, shows how different industrial sectors rank the relative importance of universities and science to their innovative capabilities.
The university-industry interactions consolidate and develop the national innovation system and should be understood as its constituent part. However, the intensity of the relationship depends on the structural absorption capacity of the actors involved according to Meyer-Schmoch and Kramer (1998). The characteristic of the university-industry interaction is specific to each country and each region, being dependent on the national infrastructure of science and technology. According Rapini and Righi (2007), in Brazil, a significant part of the interactions between university-industry has an unidirectional flow, i.e., it comes from universities and institutions to the firms.

Studies have indicated that the relationship between industry and universities vary with the level of the personnel involved, and committed resources (SANTORO, 2000), and these relationships include components such as support for research, cooperative research, knowledge transfer and transfer of technology.

From the literature available at the time, Bonaccorsi and Piccaluga (1994) built taxonomy of the types of university-industry relationship, which main variable is the organization, preparation and commitment of organizational resources in terms of personnel, equipment and financial resources between the two parties involved in the relationship. The authors present six forms of cooperation classified according to the organizational resource surrounded by the university, taking into account the duration of the agreements terms and the degree of formalization: i) informal personal relationships, without the involvement of the university; ii) formal personal relationships, agreements between universities and firms; iii) involvement of an intermediary institution; iv) formal agreements with definite purpose; v) formal agreements without defined purpose, type "umbrella"; vi) creation of specific structures for interaction.

Geisler (2001) points out that interactions between universities and industry become an organizational reality when professionals involved transform the UII in a well-structured formal cooperative relationship or alliance, making it part of the routine in the processes of acquisition and integration of technology and this goes on to compete for resources and management attention to its success and sustainability.

Considering the varios types of university-industry interactions related, it can be understood that the types of UII is classified in two categories: use of knowledge and use of infrastructure. From this, the first two hypotheses arise:

**H1** - The university-industry interactions based on the use of the knowledge available at the university positively influences the product innovation intensity and process of the company.

**H2** - The university-industry interactions based on the use of the infrastructure of the university positively influences the product innovation intensity and process of the company.

To understand the influence of public funding of the university interaction activities with the industry, in the next section, the aspects of these fundings of innovation in Brazil will be addressed.

### 3. Public funding of innovation in Brazil

The literature on innovation has that the participation of the government is an important element to promote technological innovation in the country, since this is associated with the growth and development of a nation. For Fonseca (2001), the main role of the government, concerning technological innovation, is to provide the right incentives for the development and diffusion of ideas
from the private sector, and to promote a political, economic and institutional environment that encourages organizations to invest in science, technology, research and development.

In recent years the Brazilian government broaden the support for innovation, strengthening the implementation of mechanisms of support and funding, especially for firms in the information technology sector and other related to this. According to the Brazilian Council Funding for Studies and Projects - FINEP (FINEP, 2013), Brazil's industrial structure is changing, and more firms are using innovation as a growth strategy. The construction of a more robust system of innovation is observed, coupled with the implementation of graduate programs at universities and the creation of special funds for research (Salerno; Kubota, 2008).

Since 2005, Brazilian government released a set of instruments to support innovation, as well as the designation of institutions to assist in this movement. The FINEP is one of the public institutions of private law under the Ministry of Science Technology and Innovation (MCT&I), that promotes and finances innovation through scientific and technological research in industry and scientific institutions, mobilizing refundable or non-refundable financial resources to promote innovation in Brazil (FINEP, 2013).

In addition to direct funding of innovation there is also the provision of fiscal incentives to reduce the cost and risk of R&D projects, operated as a deduction from income tax and tax credit.

The Brazilian government has structured federal and state funding lines for innovation, by means of direct incentives, economic subventions calls for innovation in firms which, according to FINEP (2013), is a government policy instrument widely used in developed countries, operated in accordance with the rules of the World Trade Organization (WTO). This type of financial support consists in the application of non refundable public resources directly in firms, to share with them the costs and risks inherent in such activities. Launched in Brazil in August 2006, this was the first time that such an instrument was available in the country, and its development banks, as FINEP, National Bank for Economic and Social Development (BNDES) and others state research foundations.

The access to financial resources offered by FINEP can be accomplished through partnerships in university-industry cooperation projects through loans to an interest rate subsidized by sectoral funds or through economic subsidies or direct subsidies, offered through public calls (Araújo, 2012). Corder (2009), highlights the refundable financial support, Venture Capital and Private Equity, Tax incentives and non-refundable financial support as the main funding mechanisms and incentives for innovation, which seek to expand the amount of financial resources and their allocation on innovation activities.

Studies from Rapini and Oliveira Neto (2013) show evidence that the nature of public funding seems to influence the motivation of cooperation between industry and universities, as they induce firms to participate in cooperative projects of greater risk, cost and complexity.

The economic support to innovation is one of the main instruments of the government's development policy, being operated according to the rules of the WTO (FINEP, 2010). Created from the approval and regulation of the “Innovation Law” (Law 10.973 of 12/02/2004) which is intended to cover the operating expenses of innovation activities (personnel, materials, third party patent offices, conservation and adaptation real estate for innovation) and the “Good Law” (Law 11.196 of 11/21/2005) which is intended for the reimbursement of the value of the remuneration of master and doctor researchers hired by the firms, this mode allows the use of non-refundable resources directly in Brazilian firms that develop innovation projects, sharing the costs and risks inherent in such activities.
The purpose of the grant, to Costa, Szapiro and Cassiolato (2013), is to enable the development of innovative processes and products to occur with public calls which establish support to innovation projects only and not to projects in research and development stages, focusing on the potential outcome and not on the overall innovation strategy of the company. Thus, in case of technical success, it is expected that the company has the necessary conditions so that the result of the subsidized project can reach the market.

Costa, Szapiro and Cassiolato (2013) conducted an analysis of calls launched in Brazil between the years of 2006-2010, in which one can observe that each given notice, new rules governed the fundings, such as distinct areas and topics that could be supported; changes in relation to the price charged; new requirements in relation to the size of the company; establishment of minimum and maximum values for funding proposals; among others, significantly changing the rules of the Program Grant for Innovation.

From the discussion presented and the characteristics of the public funding for innovation in Brazil, it is possible to define hypotheses 3, 4 and 5:

**H3** - *The use of public funds to finance the activities developed in the university-industry interaction positively influences the innovative results of the company;*

**H4** - *The university-industry interactions based on the use of the knowledge available at the university, mediated by the use of public resources, positively influences the innovative results of the company;*

**H5** - *The university-industry interactions based on the use of university infrastructure, mediated by the use of public resources, positively influences the innovative results of the company.*

4. Methodological aspects

To evaluate the hypotheses constructed, a database was created to set up a survey from the scientific project entitled "Interaction of Universities and Research Institutes with firms in Brazil." This research has been prepared by a group of researchers from several Brazilian universities.

The database contains information about firms who had relationships with research groups registered in the 2004 Census of the National Council for Scientific and Technological Development (CNPq) Directory of Research Groups. This cut has generated a total of 1,688 firms, of which 325 responded the survey, representing 19.3% of the population.

The data collection was conducted in 2009, using a structured questionnaire sent to firms. The questionnaires were constructed to understand the perception of the importance of various aspects of interactions. In the questions about interactions, the surveyed ascribed a grade of 1-4, where: 1 - unimportant; 2 - somewhat important; 3 - moderately important; and 4 - very important. The responses were tabulated and organized.

After the descriptive analysis, it was created a factorial analysis of the types of university-industry interaction, due to the amount of types. Subsequently, a regression was developed for each of the four types of defined model.
4.1 Firms characterization

Regarding location, the 325 firms concentrated in greater numbers in the Southeast and South of Brazil (79.7%). Of these 79.7%, 77 firms surveyed, are located in the state of Minas Gerais, 60 in Rio Grande do Sul, 60 in São Paulo, 29 in Santa Catarina, 18 in Parana and 15 in Rio de Janeiro; with the remaining 18.3% distributed in other Brazilian states.

Considering the firm’s size, following the criteria of the Brazilian Support Service for Micro and Small Enterprises (SEBRAE) for industrial firms, it is observed that there is a balanced distribution: 34.2% are large (over 500 employees), 31.4% are medium (100-499 employees) and 33.5% are small and micro businesses (fewer than 99 employees).

The origin of the capital is predominantly private-national, accounting for 69.2%; 12% is private-foreign, 5.8% are public firms and the rest are mixed capital firms.

According to the field of activity, mainly group is formed by manufacturing enterprises (62.8%), and it is observed a balance in the distribution among the four categories of technology-intensive industrial activities, according to the OECD (2003), high-technology industries, medium-high-technology industries, medium-low-technology industries, low-technology industries.

Regarding the R&D activities, the average number of employees involved is 28.5 employees per company. It was observed that 84.4% of the firms claimed that their R&D activities are continuous, meaning that they occur frequently (not sporadic). Of the total, 67.1% of the firms surveyed reported having an R&D department.

The surveyed firms have long-term relationships with universities or research institutes. The data indicate that: 32.9% of the firms have cooperation with universities or research institutes for a period between 5 and 10 years, and 34.9% of the firms claim to have relations with universities or research institutes for more than 10 years.

Regarding the funding of R&D projects in collaboration with universities or research institutes, it turns out that the source is the company itself (63.7%). Nevertheless, only 18.1% of firms carried out projects with the use of public resources.

4.2 Dependent variables

With the objective of detecting results of interactions and the use of public resources, Table 1 shows the two dependent variables that were set.
Table 1 – Dependent variables characteristics

<table>
<thead>
<tr>
<th>Code</th>
<th>Variable</th>
<th>Expected Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPROD</td>
<td>Product innovation.</td>
<td>+</td>
<td>Continuous variable where: 0 - no innovation or no answer; 1 - improvement of existing products; 2 - new product to the company; 3 - new product to the country; 4 - new product to the world.</td>
</tr>
<tr>
<td>INPROC</td>
<td>Processes innovation.</td>
<td>+</td>
<td>Continuous variable where: 0 - no innovation or no answer; 1 - improvement of existing products; 2 - new product to the company; 3 - new product to the country; 4 - new product to the world.</td>
</tr>
</tbody>
</table>

Source: elaborated by authors.

4.3 Independent variables

As the data showed several types of interaction, namely the interactions tend to be different according to each firm, it became necessary grouping the types of interaction. With this, we obtained a smaller number of types of interactions to be analyzed at the end of the work. Of the eleven types of interactions available in the questionnaire as a possible response, we came up with two factors, by means of a factorial analysis. With this analysis we sought to identify a pattern of correlations over a smaller number of variables (factors) than the original number.

The two factors are: (factor 1) interactions based on the use of the knowledge available at the university and (factor 2) interactions based on the use of physical structure of universities. In Table 2, the interaction types comprising each factor can be visualized. These factors were then used as independent variables in the regression, to then obtain the results of the importance of the interaction. In other words, rescuing the general objective of the study, these factors will be used in the regressions to understand the impact of the type of interaction and public resource use in the innovative performance of the company.
Table 2 – Factorial analysis of interaction types

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factors' variables</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Factor 1: Interactions based on the use of the knowledge available at the university</td>
<td>Use of publications and reports</td>
<td>0.740</td>
</tr>
<tr>
<td></td>
<td>Public meetings and conferences</td>
<td>0.751</td>
</tr>
<tr>
<td></td>
<td>Informal exchange of informations</td>
<td>0.703</td>
</tr>
<tr>
<td></td>
<td>Hiring of graduates from university</td>
<td>0.670</td>
</tr>
<tr>
<td></td>
<td>Individual researchers consulting</td>
<td>0.577</td>
</tr>
<tr>
<td></td>
<td>Commissioned research to the university</td>
<td>0.615</td>
</tr>
<tr>
<td></td>
<td>Research conducted jointly with the university</td>
<td>0.711</td>
</tr>
<tr>
<td>Factor 2: Interactions based on the use of physical structure of universities.</td>
<td>Incubators</td>
<td>0.806</td>
</tr>
<tr>
<td></td>
<td>Science and technology parks</td>
<td>0.798</td>
</tr>
<tr>
<td></td>
<td>The company belongs to the university</td>
<td>0.845</td>
</tr>
<tr>
<td></td>
<td>The company is a university spin-off</td>
<td>0.804</td>
</tr>
</tbody>
</table>

Source: elaborated by authors.
Obs.: The data were analyzed by extraction of the main components and by varimax rotation method with Kaiser normalization.

In addition to the above factors, Table 3 below shows the independent variables used in the eight regressions, four of regressions (Models 1 through 4) for innovative performance in terms of product innovation and four regressions (Models 1 through 4) for innovative performance in terms of process innovation.
Table 3 – Independent variables characteristics

<table>
<thead>
<tr>
<th>Code</th>
<th>Variable</th>
<th>Expected Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE ***</td>
<td>Size of the company.</td>
<td>+</td>
<td>Logarithm of the number of employees, indicating the size of the company.</td>
</tr>
<tr>
<td>PUBREC</td>
<td>Use of public resources.</td>
<td>+</td>
<td>Binary variable indicating whether the company used public resources (1) or not (0).</td>
</tr>
<tr>
<td>PUBREC * Factor 1</td>
<td>Relationship between public funds and interactions based on the use of knowledge available at the universities.</td>
<td>+</td>
<td>Multiplication of variable PUBREC by Factor 1.</td>
</tr>
<tr>
<td>PUBREC * Factor 2</td>
<td>Relationship between public funds and interactions based on the use of physical structure of universities.</td>
<td>+</td>
<td>Multiplication of variable PUBREC by Factor 1.</td>
</tr>
</tbody>
</table>

*** Variable control
Source: elaborated by authors.

4.4 Method of data analysis

The performed econometric exercise included two stages. At first, there was a factorial analysis (already expressed earlier), and at second, a regression of Ordinary Least Squares (OLS), whose variables are presented in Table 4. The empirical models, therefore, are considered by the following expressions:

(Model 1) Dependent variable = α + β₀ SIZE + ε
(Model 2) Dependent variable = α + β₀ SIZE + β₁ Factor 1 + β₂ Factor 2 + β₃ PUBREC + ε
(Model 3) Dependent variable = α + β₀ SIZE + β₁ Factor 1 + β₂ Factor 2 + β₃ PUBREC + β₄ PUBRECxFactor 1 + ε
(Model 4) Dependent variable = α + β₀ SIZE + β₁ Factor 1 + β₂ Factor 2 + β₃ PUBREC + β₄ PUBRECxFactor 2 + ε

Where, ε is a random error term.
Table 4 – Characteristics of the OLS models

<table>
<thead>
<tr>
<th>Variables to be tested</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable control - SIZE</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Types of interaction – Factor 1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Types of interaction – Factor 2</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Use of public resource</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Use of public resource x Factor 1</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of public resource x Factor 2</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Source: elaborated by authors.
Obs.: the positive sign "+" is the sign expected as a result of the regression.

5. Analysis of the results for innovation

The data analysis is presented according to the dependent variables, initially the analysis of the process innovation and later on product innovation.

5.1 Analysis of the results for process innovation

In the four analyzed regressions, the variable size of the firm (SIZE) was positive and significant. This indicates that there is a positive relationship between the innovative performance in the process innovation and the size of the company.

Factor 1 was positive and significant in all three regressions that it was analyzed, showing that interactions based on the use of the university's knowledge impact the innovative performance in the process innovation.

On the other hand, Factor 2 showed positive results, although not statistically significant. In this case, one cannot assess about the impact of interactions based on the use of physical structure of the university in innovative performance in the process innovation.

The variable public resource (PUBREC) presented a pattern on all models: negative and significant. However, there is a negative relationship between the use of public resources and the innovative performance in the process innovation. In other words, the results indicated that public funds do not contribute in this performance.

According to the moderating factor PUBREC, none had significant results. In short, for process innovation, firm size and Factor 1 showed positive and significant results; and public funds were negative and significant.
### Table 5 – Results of OLS models for process innovation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>0.326***</td>
<td>(0.069)</td>
<td>0.297***</td>
<td>(0.069)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.296***</td>
<td>(0.069)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.301***</td>
</tr>
<tr>
<td>Factor 1</td>
<td>0.192***</td>
<td>(0.063)</td>
<td>0.189*</td>
<td>(0.077)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.191***</td>
<td>(0.62)</td>
</tr>
<tr>
<td>Factor 2</td>
<td>0.062</td>
<td>(0.062)</td>
<td>0.062</td>
<td>(0.062)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.111</td>
</tr>
<tr>
<td>PUBREC</td>
<td>-0.226*</td>
<td>(0.128)</td>
<td>-0.226*</td>
<td>(0.128)</td>
</tr>
<tr>
<td>PUBREC x Factor 1</td>
<td>0.007</td>
<td>(0.130)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUBREC x Factor 2</td>
<td></td>
<td></td>
<td>-0.145</td>
<td>(0.132)</td>
</tr>
<tr>
<td>R2</td>
<td>0.0644</td>
<td>0.1025</td>
<td>0.1025</td>
<td>0.1059</td>
</tr>
<tr>
<td>N. observations</td>
<td>325</td>
<td>325</td>
<td>325</td>
<td>325</td>
</tr>
</tbody>
</table>

Source: elaborated by authors. 
Obs.: ***, ** and * represent 1%, 5% and 10% significance levels, respectively. Standard error in parentheses.

### 5.2 Analysis of the results for product innovation

In the analyzed four regressions, the variable size of the firm (SIZE) was positive and significant, but with lower significance level when compared to the process innovation.

Factor 1 showed positive results, although not statistically significant. The same can be seen for Factor 2, with the exception of Model 4, where the result was significant at 10%.

The variable public resource (PUBREC) presented a pattern on all models: negative and not significant. According to the moderating factor PUBREC, we met a pattern in the expected signal, both negative. However, only Factor 2 * PUBREC was statistically significant.

In short, for product innovation, the company's size and Factor 2 (in Model 4) had significant results. On the issue of firm size, there is a positive relationship, i.e., the larger the company, the greater the innovative performance for product innovation. Regarding Factor 2, it can be said that the use of the physical structure of the innovative universities positively affected the performance of the company to product innovation. This result is close to what can be seen in Brazilian industrial reality of large firms, representing that the physical structure is more beneficial for the development of innovation in product than in process. However, when exercising Factor 2 moderated with public funds, the results showed a negative sign and significance level of one percent. This finding may reveal insights about the profile, type or form of public funding for innovation in Brazil as they do not necessarily consider the risks involved and sometimes require results of entrepreneurs.
Table 6 – Results of OLS models for Product Innovation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>0.144*</td>
<td>0.130*</td>
<td>0.133*</td>
<td>0.142*</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.077)</td>
<td>(0.077)</td>
<td>(0.076)</td>
</tr>
<tr>
<td>Factor 1</td>
<td>0.090</td>
<td>0.114</td>
<td>0.089</td>
<td>0.152*</td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.086)</td>
<td>(0.070)</td>
<td>(0.084)</td>
</tr>
<tr>
<td>Factor 2</td>
<td>0.012</td>
<td>0.013</td>
<td>-0.229</td>
<td>-0.421***</td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.070)</td>
<td>(0.141)</td>
<td>(0.146)</td>
</tr>
<tr>
<td>PUBREC</td>
<td>-0.202</td>
<td>-0.200</td>
<td>-0.067</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.143)</td>
<td>(0.143)</td>
<td>(0.145)</td>
<td></td>
</tr>
<tr>
<td>Factor 1 x PUBREC</td>
<td></td>
<td></td>
<td></td>
<td>-0.421***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.146)</td>
</tr>
<tr>
<td>Factor 2 x PUBREC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>0.0110</td>
<td>0.0221</td>
<td>0.0228</td>
<td>0.0470</td>
</tr>
<tr>
<td>N. observations</td>
<td>325</td>
<td>325</td>
<td>325</td>
<td>325</td>
</tr>
</tbody>
</table>

Source: elaborated by authors.
Obs.: ***, ** and * represent 1%, 5% and 10% significance levels, respectively. Standard error in parentheses.

6. Final remarks

The intention of this final section is to summarize the conclusions achieved by the brief study compiled in the sections previous ones. This paper aims to contribute to the discussion about the relationship among public funding, university-industry interactions and firm’s innovation, considering the Brazilian firms characteristics of innovation. It was supposed that there is a positively influence between the university-industry interaction and the results of firm’s innovation, and that the results of firm’s innovation is positively influenced by the use of public funds to finance the activities developed in the university-industry interaction.

The analysis of the results from the empirical strategy indicate some final remarks, considering every hypothesis.

The university-industry interactions based on the use of the university’s knowledge has a positive and significant relationship with firm’s product innovation, confirming the first hypothesis regarding product innovation.

Considering the results of Model 4, the university-industry interaction based on the use of the university’s infrastructure is positive and significant to firm’s product innovation, confirming the second hypothesis regarding product innovation.

The use of public funding has negative and significant relationship with firm’s process innovation, disproving the third hypothesis.
It was identified a negative and significant relationship between the use of public funding and the university-industry interaction, disproving the fourth and five hypothesis. Some observations about this result are:

- the type of funding used in public incentives (mainly grants and non-repayable loans) may be influence the negative relationship between the use of public resources and the university-industry interaction;
- constant changes in the funding rules should influence the use of it, but not the establishing of interactions; and
- it seems plausible – in Brazilian cenario - consider that ‘grant’ as investment in R&D may not be generating a virtuous circle in firms, but, replacing the firm’s investment - some academic studies indicate that -, making it difficult to have a continuous innovation process in firms.

Finally, our results suggest that the firm’s size is a factor that influence the generation of process and product innovation.

It is import to note some specificities of Brazilian context considering the relationship among public funding, its effectiveness for the firm’s innovative activity and the university-business interaction. This is because the practice of interaction is not the most sought by firms that claim to innovate in Brazil, where the innovative activity relates more centrally to purchase modern machinery and equipment and interaction with customers and suppliers (according 2011 PINTEC’s data) (IBGE, 2011).

Finally, it is clear that the issue is complex and it is necessary continue searching and revealing characteristics about the university-industry interaction’s process, the public funding and firm’s innovative activity.

7. References


1 The ‘Research Innovation’ (PINTEC) is conducted by the Brazilian Institute of Geography and Statistics (IBGE).


