

**INTERAÇÃO UNIVERSIDADE-INDÚSTRIA E OS EFEITOS NA INOVAÇÃO DAS EMPRESAS:  
EVIDÊNCIA EMPÍRICA DE COMPANHIAS BRASILEIRAS.**

**RESUMO**

Este trabalho investiga a interação universidade-indústria e seus efeitos sobre a probabilidade de inovação de produtos e processos em um país em desenvolvimento. Especificamente, discute-se que as empresas diferem em tipos e aspectos determinantes para interagir com as universidades e estas diferenças podem proporcionar resultados de inovação distintos. Coletamos e analisamos dados primários de 325 companhias que possuíam alguma interação com universidades em anos anteriores. Os resultados de regressão logística suportaram nossos argumentos, demonstrando como os diferentes tipos de interação proporcionam diferentes resultados de inovação.

**Palavras-chave:** Inovação; Universidade-Indústria; Parcerias Estratégicas.

**EFFECTS OF UNIVERSITY-INDUSTRY INTERACTION ON FIRM'S INNOVATION: EMPIRICAL  
EVIDENCE FROM BRAZILIAN FIRMS.**

**ABSTRACT**

This paper investigates the university-industry interaction and its effect on the likelihood of product and process innovation, in a developing country. We argue that firms differ in the type and determinants of interactions with universities and these differences may result in different innovation outcomes. We collected and analyzed primary data from 325 firms that had any interaction with universities in previous years. Logistic regression results provide some support for our argument by demonstrating how different types of interaction result in different innovation outcomes.

**Keywords:** Innovation; University-Industry Interaction; Strategic Alliances.

**EFEITOS INTERACÇÃO UNIVERSIDADE-INDÚSTRIA E A INOVAÇÃO EN LAS EMPRESAS:  
EVIDENCIA EMPÍRICA DE LAS EMPRESAS BRASILEÑAS.**

**RESUMEN**

Este trabajo investiga la interacción entre la universidad y la industria y sus efectos sobre la probabilidad de que la innovación de productos y procesos en un país en desarrollo. En concreto, se argumenta que las empresas se diferencian en tipos y determinantes para la interacción con las universidades y estas diferencias pueden proporcionar diferentes resultados de la innovación. Recopilación y análisis de datos primarios de 325 empresas que tuvieron alguna interacción con las universidades en los años anteriores. Los resultados de la regresión logística apoyaron nuestros argumentos, mostrando cómo los diferentes tipos de interacciones dan diferentes resultados de la innovación.

**Palabras clave:** Innovación; Universidad-Empresa; Alianzas Estratégicas.

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## 1 INTRODUCTION

Universities have a key role in our society because they are important sources of knowledge and technical development, which in turn may be used by firms to develop products and enhance processes (Nelson, 1993; Etzkowitz et al., 2000; Mowery & Sampat, 2007). On the other hand, firms provide information about applied problems so universities can drive their efforts to find solutions for such problems, becoming entrepreneurial universities (Rosenberg, 1983; Nelson, 1996). Many studies have investigated the drivers for interaction between university and firm (Bonaccorsi & Piccaluga, 1994; Geisler, 1995; 2001; Meyer-Krahmer & Schmoch, 1998; Mytelka, 2000; Doloreux, 2002; Bruno & Orsenigo, 2003; Asheim & Gertler, 2007) and how these interactions are characterized (Bonaccorsi & Piccaluga, 1994; Meyer-Krahmer & Schmoch, 1998; Santoro, 2000; Geisler, 2001). Some studies have investigated the influence of such interaction to firm innovation (Santoro, 2000; Geisler, 2001; Monjon & Waelbroeck, 2003; Belderbos et al., 2004; Faems et al., 2005; Cassiman & Veugelers, 2006; Balconi & Laboranti, 2006; Giuliani & Arza, 2009). However, most studies have been conducted in developed countries and very few in developing countries, such as Brazil, Russia, China, and India. These countries are in a different stage of development and this may have an impact, not only for innovation outputs, but also for innovation initiatives like the interaction between universities and firms. In addition, few studies have distinguished the reasons firms look for interaction with universities and how these reasons may be related to the types of interactions formed. For example, some firms may interact with universities to obtain access to resources that are scarce for them but abundant for universities, while other firms may interact with universities to obtain knowledge from specialized professionals, much like a consultancy service. These motives to interact may influence the type of interaction between them, which in turn may have an impact on their outputs.

Despite the fact that traditional literature does not establish a direct relationship between the university-industry interaction and innovation, there are important studies that reveal this possibility. Success in innovation depends, not only on combining various innovation activities, but also on creating a context where the innovation process relies on basic R&D, affecting the strength of the complementarity between innovation activities (Cassiman & Veuglers, 2005). Cohen and Levinthal (1990) and Sparrow and Tarkowski (2009) argue that the absorptive capacity of firms can be enhanced through the interaction with the university, generating innovation for the firm. From a managerial viewpoint, the cooperation between university and industry is an effective approach to

enhancing firm's innovation performance (Guan & Zhao, 2013). So it is reasonable suggest the research question: Is there any relationship between the reasons and forms of university-industry interactions with the firms innovation?

In order to answer the research question, the objective of this paper is twofold. First, we investigate the relationship between reasons and types of university-industry interaction. More specifically, we conceptually define and empirically investigate how reasons and types of interaction may exist based on literature and empirical data. Second, we explore how different types of interactions may be related to innovation outputs in a developing country. More specifically, we try to understand how types of university-industry interactions are related to product and process innovation in a developing country. Our study differentiates from others in the literature by focusing on reasons and types of interaction in an attempt to qualify the interaction between universities and firms. Other studies have empirically demonstrated the benefits of interaction but do not qualify these interaction. We believe that the innovation outputs tend to be different depending on the reasons and types of interaction and this is our main theoretical hypothesis.

## 2 LITERATURE REVIEW

### 2.1 The Interaction Between University And Industry

The interaction between universities and industry (U-I interaction) can be viewed as the forms by which universities and firms relate to each other. These interactions can take several forms. For example, one form of interaction is to contract universities to perform services for firms such as technical consulting. Another form is to hire recent graduate students from universities. There are many other forms of interactions and some are more intense and deeper than others, which, in turn, may have an effect on firms' ability to innovate. In this context, universities are viewed as central agents in innovations systems (Nelson, 1993; Etzkowitz et al., 2000) because they are the major source of knowledge that is necessary for basic research (Nelson, 1990) as well as for specialized knowledge for application by firms in product development activities (Klevorick et al., 1995). In addition, universities are responsible for education and training of professionals who are responsible for solving problems that lead firms to innovation (Rosenberg & Nelson, 1994). Another contribution is to provide support and the proper environment for creation of technology-based companies, also called *spin-offs* (Stankiewicz, 1994).

The recognition of such important contributions of universities to innovation has led governments of developed countries to develop initiatives to approximate universities and innovative firms (Mowery & Sampat, 2007). Some of these initiatives include the creation of technology parks, firm incubators, support to small ventures, among many other ways of supporting the interaction between universities and firms. The major objective of these initiatives is to boost economic development through the research conducted by universities. From an academic perspective, there are a growing number of studies whose central concern is to investigate and understand the relationship between universities and firms (Bonaccorsi & Piccaluga, 1994; Fritsch & Schwirten; 1999; Mowery et al., 2001; Cohen et al., 2002; Bruno & Orsenido, 2003). Most research, though, has been done in developed countries, and very little is known about the interaction between universities and firms in developing countries.

Studies about the interaction between universities and firms in developing countries have begun to emerge in the literature. In a work conducted in Chile, Giuliani & Arza (2009) found mixed results with some evidence supporting the relationship between universities and firms and some evidence not supporting it. In a study developed in Bolivia, Vega-Jurado et al. (2008) argue that the interaction between university-industry has been built based on scientific research activities that are irrelevant for that country. Nwagwu (2008) conducted a study in Nigeria and found that the strong involvement of government and the technology gap are the main barriers for university-industry interaction. In South Korea, Eom & Lee (2010) found that traditional determinants of interaction between universities and firms have no impact for innovation. In Thailand, Brimble & Doner (2007) revealed that university-industry interaction is fragile and results in low levels of innovation. In their study in China, Wang & Lu (2007) state that institutional mechanisms are needed to stimulate knowledge transfer between universities and firms as well as to develop an entrepreneur spirit in universities. Eun et al. (2006) attempt to determine what conditions universities should have to become entrepreneurs: resources, absorptive capacity, existence of intermediary institutions, and interest in maintaining the relationship with firms. In a study conducted in Brazil, Rapini & Righi (2007) affirm that, in most cases, the interaction between university and firm is unidirectional in which the university provides information and knowledge for the firm but does not receive a firm's counterpart in terms of a positive and reinforcing feedback. Taken together, these studies provide empirical evidence that challenge the results found in research conducted in developed countries and lead to some skepticism about how these results can be applied for interaction between universities and firms in developing countries.

## 2.2 Types of University-Industry Interaction

Much research in the literature suggests that the cooperative relationship between universities and firms vary according to the level of general and human resources employed in the relationship (Santoro, 2000). This cooperative relationship encompasses elements that support research, cooperative research, and knowledge and technology transfer mechanisms.

Bonaccorsi & Piccaluga (1994) developed a typology of relationships between universities and firms. The major variable in their typology is the resources shared between a given pair of university and firm, such as human resources, equipments, and financial aid. The typology includes six forms of a cooperative relationship classified according to the resource employed in the relations along with the time and level of formalization:

- a) Informal personal relationship – occurs when a university professor interacts with firm managers to exchange information but with no formal cooperative agreement between university and firm;
- b) Formal personal relationship – the type of relationship that occurs through the establishment of a formal agreement between a university professor and the firm;
- c) Third-party involvement – a third firm or institution is responsible for mediating the relationship between university and firm;
- d) Formal specific agreement – the relationship is based on a formal agreement designed to achieve specific goals and is over after the goals are achieved;
- e) Formal general agreement – the relationship is based on a formal agreement designed to show the intention of both parties to cooperate in the future;
- f) Interaction structures – the relationship where both university and firm develop a specific structure to accommodate the interaction between them.

Geisler (2001) argues that university-industry interactions become real for organizations when people engaged in such interactions transform these interactions into a formal and structured cooperative relationship. In this case, the relationship is incorporated in firm and university routines and become part of technology acquisition and integration processes.

## 2.3 Determinants of University-Industry Interaction

Determinants of university-industry interaction can be viewed as those factors that shorten the distance between universities and firms and lead them to start a relationship. The resource-based view (RBV) is one important theoretical framework to help determine the university-industry interaction (Penrose,

1959; Wernerfelt, 1984; Barney, 1991) because this theoretical perspective views resources as assuming a major role in firm growth and success. According to RBV underpinnings, if the firm does not have the necessary resources for its prosperity, then the firm will search for resources in the environment. In the case of university-industry interaction, then, the interaction tends to happen if the firm needs resources that the university has available (Axelrod, 1984).

Following the extant literature, mostly focused on developed countries, the main determinants for university-industry interaction are detailed below.

### 2.3.1 Firm Reasons To Interact

The literature suggests that the benefits obtained from the interaction between university and firm are one of the main drivers for such interaction. For instance, by interacting with universities, firms can quickly improve their technology capacity without too much investment. According to Bonaccorsi & Piccaluga's (1994) classification scheme, firms seek interaction with universities in order to (i) access advanced scientific knowledge, (ii) increase science predictive power, (iii) outsource specific product development tasks, and (iv) get access to overall resources. Firms also search for interaction with universities to obtain prestige and to enhance their reputation by associating their brand with that from universities (Santoro, 2000).

### 2.3.2 Firm Characteristics

Several studies suggest that firm characteristics, like lack of resources and size, may be associated with greater university-industry interaction (Segarra-Blasco & Arauzo-Carod, 2008; Veugelers & Cassiman, 2005). For example, because of their lack of resources, small and medium firms tend to interact more often with universities. Tether (2002), on the other hand, states that big firms obtain better results in such interaction because these firms have more internal resources than small and medium firms, and thereby, can make better use of information and knowledge acquired during the interaction. In addition, differences in industry characteristics are also associated with greater university-industry interaction. Differences in growth technology rate (Klevorick et al., 1995; Malerba, 2002; 2004) as well as in industry structural innovation pattern (Pavitt, 1984) help to explain differences in amount of university-industry interaction. Other studies also support the idea that advancement in some industries depends primarily on scientific and technology improvements (Mayer-Krahmer & Schmoch, 1998; Santoro & Chakrabati, 2002). In this study, firm characteristics will be used as a control variable so we can control for the effect of the firms size on their innovation outputs.

The organizational structure, managerial behavior, employees' entrepreneurial mindset,

managerial support, and firm absorptive capacity (Cohen & Levinthal, 1990; Geisler, 2001; Bonaccorsi & Piccaluga, 1994) are firm characteristics related to the R&D structure. Research and development intensity is another fundamental firm characteristic for such interaction (Scherer, 1980), and it can be viewed as a proxy for absorptive capacity because firms with higher research and development intensity are more likely to acquire external knowledge from a partnership with a university. Although the lack of consensus, some studies suggest that higher research and development intensity leads to higher technology development. However, firms can also develop technology internally, rather than cooperating with other firms and/or universities (Love & Roper, 1999). Because investment in research and development activities may have a direct impact on innovation outputs, we decided to use this determinant as a control variable in our study.

### 2.3.3 Public Policies

The role played by government in developing public policies is also crucial for university-industry interaction. By creating laws and establishing norms, the government facilitates the interaction between universities and firms, provides incentives for innovation, and protects owners' property rights (Dodgson, 1993; Mansfield, 1995). The triple helix model proposed by Etzkowitz (2003) presents three means of government influence on university-industry interaction: controller, regulator, and financial supporter. In Brazil, for instance, the innovation law regulates the availability of financial resources for research projects jointly conducted by universities and firms (Brasil, 2004).

## 2.4 Innovation

For the purpose of this study, innovation can be viewed as the creation of a new product or process by a firm. The Oslo Manual (OECD, 2005) is an appropriate reference to discuss this topic because it focuses exclusively on innovation at the firm level and not at any other level. According to the Oslo Manual, a product technology innovation can be viewed as the successful implementation and commercialization of a product that has been improved and is viewed by customers as a new product or, at least, an updated version of the product. The Oslo Manual, however, distinguishes the level of product or process newness by creating four distinct, but not mutually exclusive, categories of innovation: (i) product innovation to a country - the product or process is new only to a given country; (ii) process innovation to a country - the process is new only to the country where the firm is located; (iii) product innovation to the world - the product is an innovation to all countries; and (iv) process innovation - the process is new to the whole world.

Innovation is known to be an important mechanism for economic development (Schumpeter, 1949) because innovation has an important role for technology change as well as for organizational forms. The innovation process is also systemic because firms do not work alone for development of new products or processes; they work in close collaboration with customers, suppliers, universities, research institutes, and governmental agencies, among other organizations. The way these organizations behave is, at certain point, influenced by rules, norms, laws, and existent routines, which, in turn, can facilitate or make it more difficult for these organizations to interact and innovate (Fagerberg, 2007).

### **2.5 The relationship between type of university-industry interaction and innovation**

Several studies demonstrate the positive relationship between university-industry interaction and innovation (Santoro, 2000; Geisler, 2001; Belderbos et al., 2004; Faems et al., 2005; Monjon e Waelbroeck, 2003; Giuliani & Arza, 2009). However, we believe some types of interactions are more likely to generate innovation than others. For example, a university professor informally interacting with a manager may not provide all necessary information to help the manager's firm improve its knowledge and enhance its products or processes. On the other hand, if the firm establishes a formal agreement with a specific university department to cooperate for a long term with multiple professors, the firm may exchange more information and get more knowledge from this relationship, which, in turn, may result in improvement of products and processes. Different interactions tend to yield different results because they allow different amounts of information to be exchanged by university and firm. By interacting, universities can understand the real applied problems faced by firms, while firms can get access to technical knowledge that is on the science frontier. This context of richness exchange may contribute to innovation.

### **2.6 The relationship between determinant of university-industry interaction and innovation**

After this review of the literature, we can suppose that the determinants behind the university-industry interaction may generate different results for firms because they look for such relationships in order to help them deal with specific needs. For example, many firms interact with universities to look for resources to support operations during a start-up process. Other firms relate to universities looking for specific information to solve a product development problem. Still, other firms may look for ways to test the quality of their products in a more sophisticated environment. These different types of needs may

become drivers for university-industry interactions, generating different results.

## **3 METHODOLOGY**

To conduct our study, we developed a survey questionnaire to capture different reasons and types for university-industry interactions. The questionnaire was developed according to literature review<sup>3</sup>. Because of the exploratory nature of our study, after collecting the data, we run an exploratory factor analysis to allow for different reasons and types to form groups of similar reasons and types. After obtaining the final sets of reasons and types, then we run a regression analysis to verify their effect on product and process innovation.

### **3.1 Population**

The sample frame of our study is based on the population of 1,688 firms that had any type of interaction with universities and/or research centers according to the Brazilian Council for Scientific Development (CNPq – Conselho Nacional de Desenvolvimento Científico in Brazilian Portuguese). Information about the population of firms was obtained from the following Brazilian institutions: (i) CNPq, (ii) universities, and (iii) research centers. These institutions agreed to participate in this study and provided information about firms in the population. Based on this information, we contacted each firm by phone with the purpose of explaining the objective of our study and asking for participation.

### **3.2 Respondents**

Our target respondent was the person in charge for research and development activities in each firm, such as R&D director, R&D manager and sometimes, at small firms, its owner. We sent an email with the link for a website where the questionnaire was hosted in order to have respondents participate in our survey. Each firm participated answering only one questionnaire.

### **3.3 Questionnaire**

The questionnaire employed to collect data from firms is based on an extensive literature review, which includes the Oslo Manual (OECD, 2005), to ensure validity of our measures. The questions are described below. We decided to break down the

<sup>3</sup>The questionnaire was developed in order to develop a research study denominated as Interactions of Universities and Research Institutes with Firms in Brazil. It was elaborated by a group of researchers from several Brazilian universities and coordinated by Professor Wilson Suzigan (DPCT – Unicamp) and Eduardo Albuquerque (Cedeplar – UFMG).

questions into sections corresponding to the objective of each set of questions.

### 3.3.1 Dependent Variables

The dependent variables in our study are binary variables that identify whether the firm has

products and/or processes that are innovative to its country and to the world. These variables are used later to regress the independent variables and, then, identify those that are significantly related to innovation. The questions for dependent variables are in Table 1.

**Table 1** – Questions for dependent variables

1. In the last three years, has your firm introduced new products to the market in your country? (YES or NO)
2. In the last three years, has your firm introduced new products to the market in other countries? (YES or NO)
3. In the last three years, has your firm introduced processes considered new to your country? (YES or NO)
4. In the last three years, has your firm introduced processes considered new to your country? (YES or NO)

### 3.3.2 Independent variables

The independent variables in our study are continuous variables based on a scale that vary from 1 (Not important) to 4 (Very Important).

#### 3.3.2.1 Types of interaction

To identify which type of interactions were important for firms, we asked firms the question presented in Table 2.

**Table 2** – Question for the independent variable Type of interaction

5. Please, choose, from “1”(Not important) to “4”(Very important), the importance of each of the interactions below you have had with universities:
a) Publications and reports
b) Public conferences and encounters
c) Research accomplished together with the university
d) Informal information exchange
e) Post-graduated or graduated staff hired
f) Research ordered from the university
g) Participation in university nets
h) Consultancy with individual researchers
i) Firm belonging to a university
j) Incubators
k) Firm as a university spin-off
l) Scientific and/or technological parks
m) Temporary staff exchange
n) Licensed technology

#### 3.3.2.2 Reasons for interaction

To identify which reasons for interaction were important for firms, we asked firms the question presented in Table 3.

**Table 3** – Question for the independent variable Reasons for interaction

<p>6. Please, choose, from “1”(Not important) to “4”(Very important), the importance of each of the following reasons for interaction with universities:</p> <ul style="list-style-type: none"> <li>a) Increase the ability of the firm to look for and absorb technological information</li> <li>b) Get information about engineers, scientists, and/or R&amp;D tendencies in the scientific areas</li> <li>c) Make contacts with excellent university students for future hiring, as soon as possible</li> <li>d) Transference of university technology</li> <li>e) Search for technological advice or consultancy with researchers and/or professors to solve problems regarding production</li> <li>f) Accomplish necessary tests for products and processes of the firm</li> <li>g) Contract research which cannot be accomplished by the firm</li> <li>h) Use resources available in the universities and research laboratories</li> <li>i) Receive help in quality control</li> <li>j) Contract supplementary research necessary for the innovative activities of the firm in universities and institutes, laboratories, or research centers</li> </ul>
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### 3.3.3 Control variables

To control for the effect of firm size, research, and development activity, industry, and public funds on

product and process innovation, we used the questions in Table 4.

**Table 4** – Questions for control

<p>7. What is the number of employees in your firm?</p> <p>8. What is the number of employees involved in research and development activities?</p> <p>9. Please, indicate to what extent your firm develops research and development activities: (a) occasionally or (b) continuously</p> <p>10. Please, indicate in which of the following industries your firm operates:</p> <table border="0"> <tr> <td>(a) agribusiness and silviculture</td> <td>(f) extractive industry</td> </tr> <tr> <td>(b) public services</td> <td>(g) low technology industry</td> </tr> <tr> <td>(c) information and communication</td> <td>(h) medium-low technology industry</td> </tr> <tr> <td>(d) engineering and R&amp;D</td> <td>(i) medium-high technology industry</td> </tr> <tr> <td>(e) other services</td> <td>(j) high technology industry</td> </tr> </table> <p>11. What percentage of research and develop funds come from public sources?</p>	(a) agribusiness and silviculture	(f) extractive industry	(b) public services	(g) low technology industry	(c) information and communication	(h) medium-low technology industry	(d) engineering and R&D	(i) medium-high technology industry	(e) other services	(j) high technology industry
(a) agribusiness and silviculture	(f) extractive industry									
(b) public services	(g) low technology industry									
(c) information and communication	(h) medium-low technology industry									
(d) engineering and R&D	(i) medium-high technology industry									
(e) other services	(j) high technology industry									

### 3.4 Analysis

To analyze the data, we first analyzed the distribution of our variables. All the independent variables present distribution characteristics that are close to a normal distribution, which allowed us to run a factor analysis. Secondly, we ran a factor analysis to reduce the types and reasons for interaction into few dimensions, creating factor scores to be used in the logistic regression analysis. Following the recommendation of the literature (Hair et al., 2006), we checked for the Kaiser-Meyer-Olsen and Bartlett's test of sphericity to verify conditions of the data for factor analysis. Then, we employed a principal axis factoring reduction method with varimax rotation to obtain the factors. To determine the number of factors, we rely on factors whose Eigenvalues were above 1.0. Then, we

generated new factor scores for each factor dimension based on an ordinary least square regression method. Finally, we evaluated the distribution of our dependent variables in order to determine the regression method more appropriate to the distribution characteristics of these variables. Because the dependent variables are binary variables and have a binomial distribution, we performed a logistic regression analysis (Cohen, Cohen et al. 2003, Hair, Anderson et al. 2006) regressing the types and reasons for factor dimensions on the binary dependent variables: product and process innovation to the country and to the world.



## 4 RESULTS

### 4.1 Sample

After two waves of emails, we obtained a total sample of 325 firms (19.25% response rate). The resulting firms are predominantly private-owned Brazilian firms (69.2%), while some are multinational firms (12%) and others are public state-owned (5.8%). Of the firms, 34.2% have more than 500 employees, while 31.4% of firms have between 100 and 499 employees; all others (33.5%) have less than 99 employees. Approximately 67% of firms declare having an R&D department. On average, firms have approximately 29 employees performing R&D related-tasks and activities. In terms of interaction with universities and research centers, 34.9% of firms have had some interaction for more than 10 years, while 32.9% of firms have had some interaction for a period between 5 and 10 years.

### 4.2 Factor Analysis

#### 4.2.1 Types of interaction

We performed a factorial analysis in order to reduce the 14 types of interactions to a smaller number of types that share a larger amount of variance. Results of Kaiser-Meyer-Olsen (0.886) and Bartlett's test of sphericity ( $\chi^2 = 1239.69$ ,  $df = 66$  p-value  $< 0.001$ ) indicate that a sufficient correlation exists among the variables to allow for factor analysis (Hair et al., 2006). Using the Eigenvalue cut-off of 1.0, two factors emerged: (i) interaction based on technical information such as publications and technical consulting provided by universities and research centers (T1); and (ii) interaction based on universities' physical resources such as incubation process of small firms in universities' facilities (T2). Table 5 provides more details about each type of interaction, factor loadings, and final components.

**Table 5** – Factor analysis results for type of interaction between university-industry

FACTOR	VARIABLES	COMPONENT	
		1	2
Interaction based on technical information (T1).	Publications and reports	0.747	
	Public conferences and encounters	0.736	
	Research accomplished together with the university	0.719	
	Informal information exchange	0.689	
	Post-graduated or graduated staff hired	0.657	
	Research ordered to the university	0.633	
	Participation in university nets	0.614	0.481
	Consultancy with individual researchers	0.571	
Interaction based on physical resources (T2).	Firm belonging to a university		0.818
	Incubators		0.796
	Firm as a university spin-off		0.788
	Scientific and/or technological parks		0.780
	Temporary staff exchange	0.436	0.623
	Licensed technology	0.440	0.581

**Note:** Extraction method: Analyses of the main components. Rotation method: Varimax with Kaiser normalization.

**Source:** Authors' research.

#### 4.2.2 Reasons for Interacting

In order to reduce the number of reasons for interacting, we performed a factorial analysis. Results of Kaiser-Meyer-Olsen (0.912) and Bartlett's test of sphericity ( $\chi^2 = 1283.38$ ,  $df = 66$  p-value  $< 0.001$ ) indicate that sufficient correlation exist among the variables to allow for factor analysis (Hair et al., 2006). Following the traditional Eigenvalue cut-off of 1.0, two reasons emerged: (i) increase firms' internal capacity (R1); and (ii) search for external physical resources (R2). Table 6 shows each type of interaction, factor loadings, and final components.

**Table 6** – Factor analysis results for reasons of interaction between university-industry.

FACTOR	VARIABLES	COMPONENT	
		1	2
Reason for the increase of the internal capacity of the firm (R1).	Increase the ability of the firm to look for and absorb technological information.	0.775	
	Get information about engineers, scientists, and/or R&D tendencies in the scientific areas	0.767	
	Make contacts with excellent university students for a future hiring, as soon as possible	0.752	
	Transference of university technology	0.707	
Reason for searching for external physical resources (R2).	Search for technological advice or consultancy with researchers and/or professors to solve problems regarding production	0.664	
	Accomplish necessary tests for products and processes of the firm		0.826
	Contract research which cannot be accomplished by the firm		0.793
	Use resources available in the universities and research laboratories		0.766
	Receive help in quality control		0.599
	Contract supplementary research necessary for the innovative activities of the firm in universities and institutes, laboratories or research centers	0.400	0.586

**Note:** Extraction method: Analyses of main components. Rotation method: Varimax with Kaiser Normalization.

**Source:** Authors' research.

### 4.3 Logistic Regression

Table 7 shows the logistic regression coefficient results for models whose dependent variables are product innovation to a country and product innovation to the world. For each dependent variable analyzed, model 3 is the one that best fit the observed data. Surprisingly, results show the type of interaction between universities and firms that is based on technical

information (Type 1) is negatively related to the development of innovative products to a given country. The odds of a firm that interacts with a university in a technical basis to come up with a product innovation is 0.58. As expected, results also show that the number of employees involved in research and development activities is strongly related to innovation to a country and to the world.

**Table 7** – Logistic regression results for innovative products to a country and innovative products to the world

Variable	PRODUCT INNOVATION TO A COUNTRY				PRODUCT INNOVATION TO THE WORLD			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
INDUS(1)	-0.047	0.320	0.313	0.035	-0.332	-0.442	-0.404	-0.387
INDUS(2)	-0.393	-0.187	-0.241	-0.376	-0.421	-0.702	-0.621	-0.431
INDUS(3)	-0.303	-0.120	-0.309	-0.434	-0.481	-0.705	-0.515	-0.322
INDUS(4)	0.465	0.754	0.567	0.322	-0.038	-0.088	0.102	0.180
INDUS(5)	0.762	0.938*	0.864	0.720	-0.244	-0.380	-0.307	-0.182
INDUS(6)	0.690	1.049	1.196	0.996	-19.884	-20.290	-20.382	-20.220
INDUS(7)	0.374	0.668	0.690	0.470	0.067	-0.117	-0.114	0.000
INDUS(8)	-0.108	-0.009	0.018	-0.020	-0.198	-0.319	-0.339	-0.281
INDUS(9)	0.169	0.253	0.239	0.176	0.365	0.218	0.251	0.395
SIZE	-0.075	-0.080	-0.104	-0.122	-0.109	-0.151	-0.136	-0.065
R&DINT	0.396***	0.522***	0.537***	0.457***	0.583***	0.533***	0.533**	0.548***
PUBRES	-0.210	-0.128	-0.126	-0.205	-0.031	-0.063	-0.056	-0.022
Type1		-0.543***	-0.481***			0.228	0.154	0.369**
Type2		0.047	0.087			0.032	-0.011	
Reason1			-0.026	-0.167			0.045	
Reason2			-0.224	-0.299**			0.219	
Constant	-1.594***	-2.246***	-2.260***	-1.664***	-2.576***	-2.988***	-3.025***	-2.655***
(-2LL)	381.562	367.475	365.368	375.038	285.970	275.100	273.762	279.319
(C&S R <sup>2</sup> )	0.054	0.095	0.101	0.073	0.077	0.107	0.110	0.095
(H & L)	0.402	0.455	0.136	0.455	0.203	0.034	0.533	0.456

(-2LL) = Log Likelihood ; (C&S R<sup>2</sup>) = Cox & Snell R<sup>2</sup> ; (H&L) = Hosmer & Lemeshow Test.

\*\*\*, \*\*, and \* represent 1%, 5% and 10% levels of significance, respectively.

**Source:** Authors' research.

Table 8 shows the logistic regression coefficient results for models whose dependent variables are process innovation to a country and process innovation to the world. For each dependent variable analyzed, model 3 is again the one that best fits the observed data. Results also show that the

number of employees involved in research and development activities is strongly related to innovation to a country and to the world, as expected. Finally, and surprisingly, results show that firms in low technology industries are more likely to develop innovative process than firms in other industries.

**Table 8** – Logistic regression results for innovative processes to a country and innovative processes to the world

Variable	PROCESS INNOVATION TO A COUNTRY				PROCESS INNOVATION TO THE WORLD			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
INDUS(1)	0.956	0.989	1.008	1.014	-0.502	-0.687	-0.612	-0.568
INDUS(2)	0.059	0.124	0.146	0.107	0.439	0.007	0.099	0.370
INDUS(3)	-1.242	-1.193	-1.099	-1.131	-0.863	-1.206	-1.062	-0.778
INDUS(4)	-0.577	-0.572	-0.509	-0.505	0.473	0.449	0.599	0.687
INDUS(5)	0.275	0.283	0.332	0.315	0.802	0.597	0.667	0.845
INDUS(6)	0.878	0.971	0.912	0.879	0.172	-0.445	-0.488	-0.247
INDUS(7)	0.875*	0.916*	0.900*	0.883*	0.135	-0.119	-0.104	0.022
INDUS(8)	-0.023	0.001	0.015	0.002	0.920	0.779	0.741	0.796
INDUS(9)	-0.099	-0.064	-0.063	-0.102	0.357	0.151	0.187	0.386
SIZE	0.361*	0.368	0.359	0.350	-0.444	-0.455*	-0.405	-0.332
R&DINT	0.294*	0.310*	0.317*	0.310*	0.686**	0.594**	0.577**	0.616***
PUBRES	-0.272	-0.261	-0.264	-0.272	-0.334	-0.341	-0.318	-0.317
Type1		-0.054	0.001			0.326	0.168	
Type2		-0.023	0.007			0.064	-0.025	
Reason1			-0.132	-0.151			0.228	0.412
Reason2			0.023	-0.005			0.251	0.441
Constant	-3.066***	-2.980***	-2.976***	-3.106***	-2.993***	-3.656***	-3.747***	-3.197***
(-2LL)	293.496	292.768	292.180	292.562	209.408	196.409	194.873	201.352
(C&S R <sup>2</sup> )	0.086	0.088	0.090	0.089	0.047	0.085	0.089	0.071
(H & L)	0.077	0.618	0.155	0.015	0.290	0.709	0.794	0.870

(-2LL) = Log Likelihood ; (C&S R<sup>2</sup>) = Cox & Snell R<sup>2</sup> ; (H&L) = Hosmer & Lemeshow Test.

\*\*\*, \*\*, and \* represent 1%, 5% and 10% levels of significance, respectively.

Source: Authors' research.

## 5 DISCUSSION

Our results suggest that firm innovation outcomes may be related to the type of interaction between the firm and universities and that firms seeking for a technical information type of interaction have decreasing likelihood of coming up with innovative products. One plausible explanation for these results may be the nature of information that serves as the basis for this type of interaction. Firms looking for interaction based on technical information are typically obtaining information that is already of common use by other actors developing innovation. For example, managers that read journal articles may get information that is already possessed by other universities and firms in the market. This kind of information may not serve the purpose of developing a new product because it might have been employed by other companies to create products.

The type of interaction may also provide a clue that helps to understand and speculate about the

innovation characteristics of firms. Firms looking for technical and already established information may have policies as well as managers who do not believe new information is worth it for their firms. This type of firm may not have the necessary resources to take advantage of new information. If we assume that this explanation makes sense, we can speculate that innovation characteristics of firms may drive the type of interaction they have with universities.

Another interesting result is the fact that firms in low technology industries tend to develop more innovation in processes than firms in high technology industries (baseline group), which is in line with Mayer-Krahmer & Schmoch (1998) and Santoro & Chakrabati (2002). It is important to note, though, that such innovativeness occurs only to the country but not to the world. Because of the perceptual nature of this research (survey data), it is possible to say that managers in low technology industries perceive themselves as developing processes that are new to their country but not to the world. Perhaps these

managers bring these processes from firms in other countries and, therefore, know that these processes are new to their country. Also, we speculate that firms in low technology industries may not be as pressured by competition with other firms to make them work hard to innovate in products as well as processes. Perhaps the low technology intensity environment faced by these firms motivate them to improve only their processes, seeking to achieve more efficiency rather than innovation.

Finally, our proxy for research and development intensity, the number of employees involved in research and development activities, is strongly related to innovation, regardless of which

## 6 CONCLUSION

Our study investigated how interaction between universities and firms can be conceptualized in different types and determinants and how they may be related to innovation outcomes. We collected and analyzed primary data from 325 Brazilian firms that have had any interaction with universities. Results show that different types of interaction may yield different innovation outcomes. For firms interacting with universities based on technical information there is a decreasing likelihood of product innovation. We could not find any empirical evidence of a relationship between some determinants of university-industry interaction and innovation. One contribution of our study is to demonstrate that firms differ in their interactions with universities and these interactions may yield different innovation outcomes.

Whereas most research on the subject of university-industry interaction uses the information of expenditure on R&D as a proxy for the intensity of R&D, this information is not always provided correctly by the firms. This work presents an alternative way of analyzing a new proxy for the intensity of R&D, consisting of the number of employees working on R&D, the definition of continuous activity, and the existence of an R&D department at the company, which seems to be useful because the results presented are consistent with previous works.

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- Another contribution is the proposition of a taxonomy to analyze the types of university-industry interactions. Two types of interactions are classified: interactions based on technical information and interaction based on university physical resources. This classification increases the possibility of obtaining significant results in the statistical analyses because it reduces the number of variables on the types of interaction. And the last contribution is to collect primary data from managers and show how firms interact with universities in an emerging country context.
- One major limitation of our study is the potential overlapping of dependent variables. Although the Oslo Manual suggestion of different levels of innovation, we may not fully capture each level enough to distinguish one from another. Even though, it seems that respondents understood these differences correctly because we obtained different results depending on the level analyzed, as in the case of low technology firms and process innovation. Future studies could address an analysis of different ways of determining innovation levels and synthesize it in a model that can be used in a more parsimonious and coherent way. Another limitation is the perceptual nature of our data that provides limited information about other characteristics of firms analyzed. A useful extension is to obtain secondary data about firms in our sample and identify additional variables that help us better understand the impact of university-industry interaction on innovation.
- type: product or process, to the country or to the world. This result was expected since research and development intensity is *per se* a condition for innovation. Thus, our findings provide empirical evidence that corroborate with findings from previous studies, demonstrating that innovation and research and development activities are strongly related such as suggested by Scherer (1980). However, we provide evidence from an emerging country, verifying that this theoretical underpinning also holds in other contexts, corroborating and complementing Giuliani & Arza (2009), Vega-Jurado et al (2008), Eom & Lee (2010) and Brimble & Doner's (2007) findings.

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