UNIVERSITY-INDUSTRY INTERACTION AND ITS EFFECTS ON FIRM’S INNOVATION: EMPIRICAL EVIDENCE FROM BRAZILIAN FIRMS.

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ABSTRACT

This paper investigates the university-industry interaction and its effect on the likelihood of product and process innovation, in a developing country. More specifically, we argue that firms differ in the type and determinants to interact with universities and these differences may result in different innovation outcomes. We collected and analyzed primary data from 325 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.

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; Ashem & 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). Hoewever most studies have been conducted in developed countries and very few in developing countries, such as Brasil, Russia, China, and India. These countries are in a different stage of development and it 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 university, 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.

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 they 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. Other form is to hire recent graduate students from universities. Like those, 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 professional 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 contribution of universities to innovation has led government of developed countries to develop initiatives to approximate universities and innovative firms (Mowery e Sampat, 2007). Some of these initiatives include, for example, the creation of technology parks, firm incubator, 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 is 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 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 interaction university-industry. 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 interaction university-industry is fragile and results in low levels of innovation. In their study about 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 firm but do 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) develop 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 cooperative relationship classified according to the resource employed in the relations along with the time and level of formalization:

a) Informal personal relationship – it 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 – it is 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 – in this type of relationship, both university and firm develops 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 make them to start a relationship. The resource-based view (RBV) is one important theoretical background to help determine the university-industry interaction (Penrose, 1959; Wernerfelt, 1984; Barney, 1991) because this theoretical perspective views resources 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 its technology capacity without too much investment. According to Bonaccorsi & Piccaluga (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 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. 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 advance in some industries depend 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 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 firms 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, then 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 ways 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 & 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 to 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

The determinants behind the university-industry interaction may generate different results for firms because they look for such relationship in order to help them deal with specific needs. For example, many firms interact with universities to look for resources to support its 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

3.1 Methodological approach

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. 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.

3.2 Sample

Our sample 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 its participation. Our target respondent was the person in
charge for research and development activities in each firm. We sent an email with the link for a website where the questionnaire was hosted in order to have respondents participating in our survey. After two waves of emails, we obtained a total sample of 325 firms (19.25% response rate).

Firms in our sample are predominantly Brazilian private-owned (69.2%), while some are multinational firms (12%) and others are public state-owned (5.8%). 34.2% of firms 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.

3.3 Independent Variables

3.3.1 Types of interaction

Types of interaction can be viewed as forms by which universities and firms interact. We provided respondents with a list of 14 different types of interaction. Using a Likert-scale ranging from 1 (“Not important”) to 4 (“Very important”), we asked them to provide their opinion about how important each type was. After computing all responses, 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. Using the traditional 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 1 provides more details about each type of interaction, factor loadings, and final components.

### Table 1 – Factor analysis results for type of interaction between university-industry

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variables</th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Publications and reports</td>
<td>0.747</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public conferences and encounters</td>
<td>0.736</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research accomplished together with the university</td>
<td>0.719</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Informal information exchange</td>
<td>0.689</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-graduated or graduated staff hired</td>
<td>0.657</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research ordered to the university</td>
<td>0.633</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Participation in university nets</td>
<td>0.614</td>
<td>0.481</td>
</tr>
<tr>
<td></td>
<td>Consultancy with individual researchers</td>
<td>0.571</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Firm belonging to a university</td>
<td>0.818</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incubators</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Firm as a university spin-off</td>
<td>0.788</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scientific and/or technological parks</td>
<td>0.780</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temporary staff exchange</td>
<td>0.436</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>Licensed technology</td>
<td>0.440</td>
<td>0.581</td>
</tr>
</tbody>
</table>

Note: Extraction method: Analyses of the main components. Rotation method: Varimax with Kaiser normalization.
3.2.2 Reasons for interacting

We provided respondents with a list of 10 reasons for firms to interact with universities and research centers. Using a Likert-scale ranging from 1 (“Not important”) to 4 (“Very important”), we asked them to provide their opinion about how important each reason was. In order to reduce the number of reasons, we performed a factorial analysis. 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 2 shows each type of interaction, factor loadings, and final components.

Table 2 – Factor analysis results for reasons of interaction between university-industry.

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

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

3.3 Dependent variables

Our dependent variables are based on the Oslo Manual (OECD, 2005) that identifies four types of innovations: product innovations, process innovations, organizational innovations, and marketing innovation. The Oslo Manual also classifies these four types of innovation according to their degree of novelty: novel to the firm, novel to the market, and novel to the world. We follow these premises to come up with four categories of product/service and process innovation: (i) product innovation to the country; (ii) process innovation to a country; (iii) product innovation to the world; and (iv) process innovation to the world. We developed one question for each category, asking respondents to indicate whether their firms developed a new product/service and process to Brazil and/or to other countries. Thus, all dependent variables are binary variables indicating the existence of product/service and/or process innovation in the firms analyzed. Because respondents were able to simultaneously indicate the existence of innovation to Brazil and other countries, that is, the responses were not mutually exclusive, we considered only the highest degree of innovation. For example, if a respondent answered that his or her firm introduced a product innovation to Brazil and to the world, we only considered the innovation to the world, the highest degree of innovation possible.
3.4 Control variables

3.4.1 Size

To control for differences in size of firms, we employed size as a control variable in our models. To measure size, we asked respondents to indicate the number of employees existing in their firms. In order to reduce the variability of this measure and make it more prone for statistical analysis, we took the natural logarithm of the number of employees (SIZE log).

3.4.2 Industry

To control for industry differences, we adopted a second control variable to classify firms according to their industry category and the technology intensity classification of the Organization for Economic Co-operation and Development (OECD), which applies when the firm follows the OECD classification (2003); otherwise, the firm is classified according to International Standard Industrial Classification – ISIC. We asked respondents to choose from one of the following industries: (i) agrobusiness and silviculture; (ii) public services; (iii) information and communication; (iv) engineering and R&D; (v) other services; (vi) extractive industry; (vii) low technology industry, (viii) medium-low technology industry; (ix) medium-high technology industry; and (x) high technology industry. Using the “high technology industry” as the baseline, we employed nine dummy variables to test for the industry effects.

3.4.3 R&D intensity

We also control for the effects of R&D intensity, since firms with a larger number of employees involved in continuous R&D activities are more likely to experience innovation than those firms with a smaller number of employees who are sporadically involved in R&D activities. This variable is composed of by the sum of the logarithm of the number of employees involved in R&D and a binary variable that considers 0 for occasional R&D activities and 1 for continuous ones. We asked respondents to indicate the number of employees directly involved in R&D activities and whether their firms developed continuous or occasional R&D activities.

3.4.4 Public policies

Finally, we control for differences in firms that make use of governmental support through public policies that provide incentives for interactions between universities and firms. We used the information of public funding as a proxy for this control variable because public policies come along with public funding to support development of specific actions. We asked respondents to provide information about the percentage of investment in innovation projects developed together with universities and research centers that comes from public funding. However, due to the high variability of answers, we transformed this variable into a binary one, assuming 0 for firms that did not get any public funding and 1 for firms that got public funding.

4 RESULTS

Table 3 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 3 – Logistic regression results for innovative products to a country and innovative products to the world

<table>
<thead>
<tr>
<th>Variable</th>
<th>Product innovation to a country</th>
<th>Product innovation to the world</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>INDUS(1)</td>
<td>-0.047</td>
<td>0.320</td>
</tr>
<tr>
<td>INDUS(2)</td>
<td>-0.393</td>
<td>-0.187</td>
</tr>
<tr>
<td>INDUS(3)</td>
<td>-0.303</td>
<td>-0.120</td>
</tr>
<tr>
<td>INDUS(4)</td>
<td>0.465</td>
<td>0.754</td>
</tr>
<tr>
<td>INDUS(5)</td>
<td>0.762</td>
<td>0.938*</td>
</tr>
<tr>
<td>INDUS(6)</td>
<td>0.690</td>
<td>1.049</td>
</tr>
<tr>
<td>INDUS(7)</td>
<td>0.374</td>
<td>0.668</td>
</tr>
<tr>
<td>INDUS(8)</td>
<td>-0.108</td>
<td>-0.009</td>
</tr>
<tr>
<td>INDUS(9)</td>
<td>0.169</td>
<td>0.253</td>
</tr>
<tr>
<td>SIZE</td>
<td>-0.075</td>
<td>-0.080</td>
</tr>
<tr>
<td>R&amp;DINT</td>
<td>0.396***</td>
<td>0.522***</td>
</tr>
<tr>
<td>PUBRES</td>
<td>-0.210</td>
<td>-0.128</td>
</tr>
<tr>
<td>Type1</td>
<td>-0.543***</td>
<td>-0.481***</td>
</tr>
<tr>
<td>Type2</td>
<td>0.047</td>
<td>0.087</td>
</tr>
<tr>
<td>Reason1</td>
<td>-0.026</td>
<td>-0.167</td>
</tr>
<tr>
<td>Reason2</td>
<td>-0.224</td>
<td>-0.299**</td>
</tr>
</tbody>
</table>

(-2LL) = Log Likelihood ; (C&S R$^2$) = Cox & Snell R$^2$ ; (H&L) = Hosmer & Lemeshow Test.
***, **, and * represent 1%, 5% and 10% levels of significance, respectively.

Table 4 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 fit 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.
Other 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). It is important
to note, though, that such innovativeness occur 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 much pressured by competition of other firms in order to make them work hard to innovate in products as well. 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 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 just provide empirical evidence that corroborate with findings from previous studies, demonstrating that innovation and research and development activities are strongly related. However, we provide evidence from an emerging country, verifying that this theoretical underpinning also hold in other contexts.

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 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. Another contribution is to come up with 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 Olso 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 come up with 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 provide limited information about other characteristics of firms analyzed. A useful extension is to obtain secondary data about firms in our sample and come up with additional variables that help us understand better the impact of university-industry interaction to innovation.
7 REFERENCES


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