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Theme: Universities as integrative partners

Title: Study of the influence of university-industry cooperation on the university researchers' ability to innovate

ABSTRACT

The ability to innovate is a resource of great importance in determining the success which an individual or company may have in their ventures. However, innovation is something difficult to obtain, both being related to the use of many fields of knowledge, as well as a high degree of uncertainty. Through studies of authors like Bonzeman e Gaughan (2007), Stal e Fujimo (2005) e Etzkowitz e Klofsten (2005), among many others, it is possible realize the importance of the university-industry cooperation in the generation of innovations. Therefore, this article sought to analyze this relation through the use of variables found in the literature, conducting a survey applied to researchers of engineering areas in the public universities of Rio de Janeiro State. For this purpose, non-parametric statistic techniques were used to analyze the data collected, showing in the results that there is a strong evidence that the contact with the industrial sector increases the ability of university researchers to innovate.

Keywords: knowledge, innovation, cooperation, non-parametric statistics.

1 Introduction

With the emergence of the new economic paradigm based on knowledge, it has become one of the main assets of the companies. According Armbrecht et al. (2001, p. 28), "knowledge is widely recognized as an important source of competitive advantage, being represented as a tangible manifestation of this knowledge."

As the speed which changes occur is increasing, it creates a continual need to innovate in order to avoid obsolescence. This implies that with the passage of time an increasing importance will be given to the management of knowledge and innovation.

According Armbrecht et al. (2001, p. 30), "Innovation is the successful exploitation of ideas to create useful new products or services". It is a process initiated by an individual or team that realize a particular market need and, try to create new ways to supply them with the application of knowledge developed so far. Yet they say, knowledge is a critical catalyst for creativity and for subsequent innovation by providing means through which innovative ideas can be captured, shared and tested. To obtain a larger number of innovations, it requires the cooperation of different institutions linking, for example, the academic and industrial environment. On the industrial side tries to meet the market needs to supply them while the academic side produces new knowledge, either directly or indirectly, helping achieving this goal. Universities are major centers of knowledge and have in their core a wide variety of disciplines. For this reason, they have great potential for the generation of innovations. However innovation is not just about new knowledge, but also imply in a useful application of it. Despite that, this view focused in the knowledge application is rarely spread at the academic circles, which are more focused on the expansion of the knowledge borders. Thus, one way of enhance the innovative capability of the universities would be made possible by combining this mindset focused in the creation of new knowledge, typical of the academic area, with the need of applying this knowledge in a useful manner, typical of the corporate vision.

Considering the need to generate more innovations to promote economic development, and the difficulty of creating links among different institutions, it is important to know which processes through these links are formed. Within this context, this paper attempts to answer the following research question:

Cooperation between academia and industry can help the innovative capacity of the research conducted in universities?

Answering to this question this research tried to identify facilitators or inhibitors variables related to innovations generated by universities and facilitators or inhibitors variables related to university – industry cooperation.

2 INSTITUTIONAL COOPERATION

Cooperation among different types of institutions to boost the innovation process is not a new idea, but it still encounters resistance to its use. Next is given a brief report on two models of development based on knowledge that has in its essence interaction among government, universities and industry.

One of the first proposals already made to demonstrate the need for iteration among different institutions was the "Sabato's Triangle", widespread in Latin America during the 60s (Etzkowitz et al., 2000). According Plonski (1995), to create this model in 1968, Jorge Sabato and Natalio Botana had as main concern overcoming this underdevelopment in Latin America through actions in the field of scientific and technological research.

This approach emphasized the state power as a leader restructuring iteration between research institutions and industry in order to facilitate the transfer of technology and generate development. However, due to this hierarchy, the model turned out to foster the creation of unilateral ties, in which the state took their decisions without taking into account the feedback from the other entities involved in the production sector (industry) and scientific-technological sector (universities and institutions research).

According to Etzkowitz et al. (2000), government agencies that used this approach to guide their research, were led to having to "guess" which potentially useful R & D could help the industry. However, in most cases, they undertook research that were not converted into marketable products.

In contrast, Sabato and Botana already in the 60's highlighted the need for a greater coordination between universities and industry, this interaction is fundamental to the society development (RIBEIRO & ANDRADE, 2007). A more complete model that also takes into account the role of the state in conjunction with industry and research institutions (universities), is the Triple Helix model proposed by Henry Etzkowitz and Loet Leydesdorff.

According Stal and Fujimo (2005), theTriple Helix model is an evolution of the Sabato's triangle, showing that besides the links among different institutional spheres, each one must perform some of the functions that were exclusive to the other two. Moreover, the model considers the formation of networks among different institutional spheres formed by helix. Thus, a more dynamic communication weis obtained and the effectiveness of the actions performed by each sphere is increased, while each institution fills the gaps left by others, adopting a more flexible approach.

In the Brazilian case, the Triple Helix is still in an embryonic state. Each institutional spheres is very attached to the specificity of their environment, contributing little to fill the gaps left by the other actors. This hinder the formation of effective networks among the state, universities and industry (STAL and FUJIMO, 2005).

For this purpose a survey was done with researchers from engineering departments in public universities located in Rio de Janeiro State. The collected data were analyzed using nonparametric statistical tools and their conclusions were based on results obtained by other authors in the literature.

2 Theoretical Background

Cooperation among different types of institutions to boost the innovation process is not a new idea, but still encounters resistance to its use. In the Brazilian case, the Triple Helix – a model representing the relationship among government, universities and industry - is still in an embryonic state, because each institutional spheres is very attached to the specificities of their environment, contributing little to fill the gaps left by other actors. This makes it difficult to form effective networks among the government, industry and universities (STAL & FUJIMO, 2005).

A literature review gave some insight to the research problem that can contribute to the research model as follow.

The research model has 9 input variables (Table 1) and 2 output variables (table 2).

Table 1: Independent variables of the model

Variables	**Operational definition**	**References**

Liaison Office or Innovation Agency	Development degree of the office responsible for the university - industry relationship	DEBACKERE & VEUGELERS, 2004; ETZKOWITZ & KLOFSTEN, 2005; JONES-EVANS *et al.*, 1999.
University visibility	How the university is known in the region	STAL & FUJINO, 2005; FERREIRA, 2006; BOZEMAN & GAUGHAN, 2007
Research mission and orientation	How well defined are the guidance and research mission of the university	COSTA, 2007; DEBACKERE & VEUGELERS, 2004; D'ESTE & PATEL, 2007; ETZKOWITZ & KLOFSTEN 2005; FERREIRA, 2006; MILLER & MORRIS, 1999; RIBEIRO & ANDRADE, 2007; STAL & FUJINO, 2005
Researcher qualifications	Titles that researcher got throughout his career	ALBUQUERQUE *et al.*, 2005; BOZEMAN & GAUGHAN, 2007; DEBACKERE & VEUGELERS, 2004; D'ESTE & PATEL, 2007; FERREIRA, 2006, STAL & FUJIMO, 2005
Past collaborations with Industry	Activities that were held in conjunction with industry	ALBUQUERQUE *et al.*, 2005; BOZEMAN & GAUGHAN, 2007; COSTA, 2007; D'ESTE & PATEL, 2007; SUZIAGN & ALBUQUERQUE, 2008
Influence of commercial factors	The factors that researchers use to motivate them to undertake a research are market-driven?	ALBUQUERQUE *et al.*, 2005; COSTA, 2007; DEBACKERE & VEUGELERS, 2005; D'ESTE & PATEL, 2007; ETZKOWITZ et al., 2000; ETZKOWITZ & KLOFSTEN, 2005; RIBEIRO & ANDRADE, 2007; STAL & FUJINO, 2005; TONELLI & ZAMBALDE, 2007

Multidisciplinary character	Necessity of different academic disciplines / knowledge to complete the research	BONZEMAN & GAUGHAN; DEBACKERE &VEUGELERS, 2005; FERREIRA, 2006; ETZKOWITZ & KLOFSTEN, 2005; HIRSCH-KREINSEN *et al.,* 2003; KLINE & ROSENBERG, 1986; MILLER & MORRIS, 1999; TONELLI & ZAMBALDE, 2007
Feasibility	The use of technical and economic feasibility studies to undertake the research	STAL & FUJINO, 2005; TONELLI & ZAMBALDE, 2007; MILLER & MORRIS, 1999, RIBEIRO & ANDRADE, 2007
Communication among Institutional Spheres	Structuring the ties among university, industry and government (in its various spheres: federal, state and municipal).	COSTA, 2007; &TZKOWITZ et al., 2000; ETZKOWITZ & KLOFSTEIN, 2005; ETZKOWITZ & LEYDESDORFF, 1999; REINC, 2008; RIBEIRO & ANDRADE, 2007; STAL & FUJIMO 2005

Table 2: Dependent Variables of the Model

Variable	**Operational Definition of Variable**	**Measurement**
Current Number of Cooperation with Industry	Present cooperation with companies	Number of cooperation
Research Developed by Researchers that can be considered Innovation	Research conducted at the University earn innovation status	Number of innovations produced

3 Methodology

A survey was done having as target faculty/researchers from engineer courses of public universities in Rio de Janeiro State, Brazil (North Fluminense State University - UENF;

Rio de Janeiro State University - UERJ; Fluminense Federal University - UFF; Rio de Janeiro Federal University - UFRJ; Rio de Janeiro University - UNIRIO). An e-mail introducing the research objectives and a link with an on line questionnaire was sent.

The statistical analysis was based on suggestions made by Siegel & Castellan (2006, p.27), starting with the establishment of a null hypothesis (H_0) and alternative Hypothesis (H_1), namely:

H_0: There is no relationship between the number of collaborations between industry and universities and the number of innovations developed via university research.

H_1: There is a relationship between the number of collaborations between industry and universities and the number of innovations developed via university research.

According to Siegel & Castellan (2006, p.53), the nonparametric tests are usually more accurate than parametric tests when samples are small and have unknown distributions, as in the case of this study. The tests chosen for this study were the Coefficient of Concordance W Kendall and Spearman's Correlation Coefficient Post-Order. The statistical analysis focused on the Spearman's Correlation Coefficient.

Gujarati (2006, p. 17th) *apud* Khul (2007) states that care should be taken in analyzes involving correlation coefficients since "a statistical relationship, by itself, cannot logically lead causation". In order to assign causality requires the support of well-grounded theoretical considerations.

3.1.1 Significant Relationships According to Spearman correlation coefficient

The focus of this analysis was to try to see some kind of causality in significant relationships found, in order to prove or disprove the observations made by other authors in the literature. But the focus of this analysis is to verify whether the most contact with the industry with universities produce more innovations through their researchers.

To try to draw a diagram of relationships among variables in order to have a more streamlined these, there was a correlation matrix with the application SPSS 15.0, in which all the variables of the problem were related to each other. The hypotheses to be tested in this initial stage are:

H0: There is no evidence that the variable A is related to variable B;

H1: There is evidence that the variable A is related to variable B.

The relationship diagram made from the correlations in which the null hypothesis was rejected (ie to a level of significance (a) <0.05) could be observed in figure 1. Therein the input variables are related to the innovation with a clearer outline as input variables related to cooperation between universities and industry are represented by a darker outline. Furthermore, the rectangular boxes represent the output variables. Each relationship has received an identification number in order to sort the explanations that will be made later. Moreover, thin lines represent significant correlations at a level of 0.05, whereas the thick represent significant correlations at a level of 0.01.

The main relationship to be analyzed at the center of the diagram (No. 14), and refers to the number of innovations generated from university research and the number of links between the university and the industrial sector (connecting the rectangular shapes).

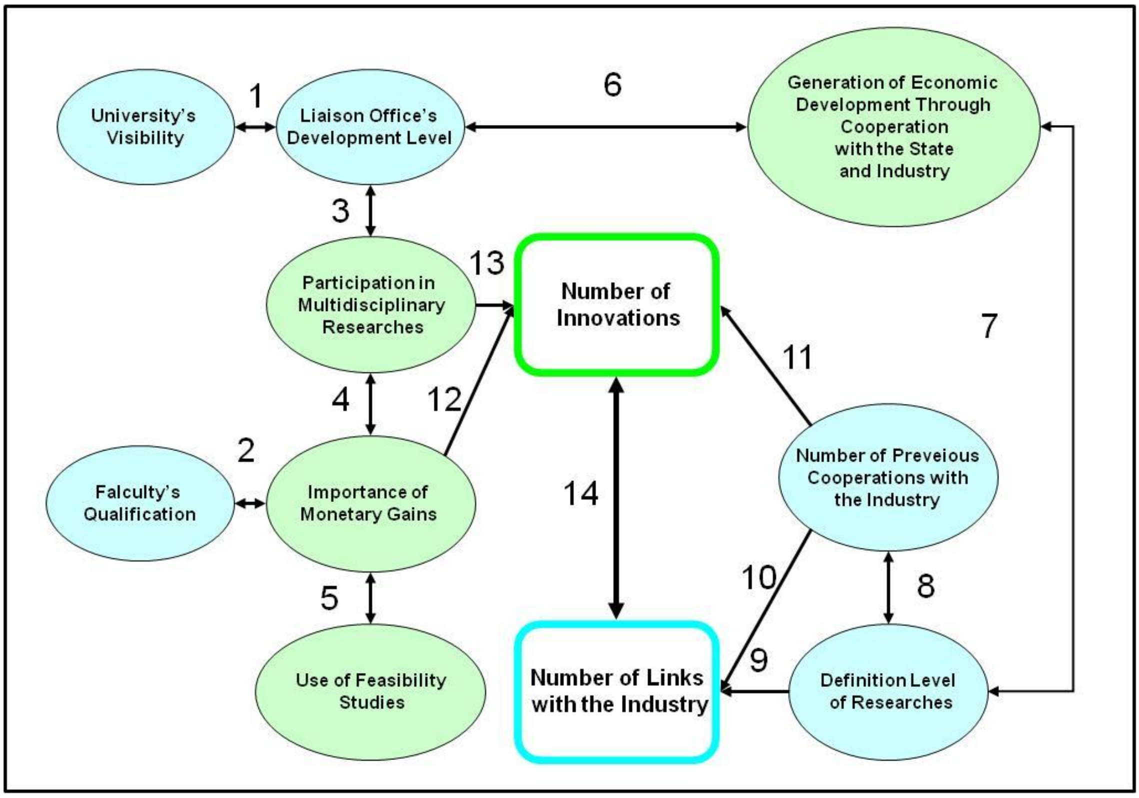

Figure 1: Correlation among the variables of the problem

Although the correlation coefficient does not show a relationship of cause and effect, we can through the literature review and the use of logical deduction to make assumptions about the causality between these variables. In order to reveal these relationships, each of the relevant correlations found was analyzed separately.

The relative number 1 refers to the connection between the degree of development of an Industrial Liaison Office (ILO) or Agency of innovation and the degree of visibility that the university has (rs (yl, vsb) = 0.39, a = .01). As can be seen in the study and Zambalde Tonelli (2007), one of the functions of the ILO's work in publicizing the functions of the university to those who might be interested. Thus, it is considered that the ILO assists the development of the visibility of the university, not the opposite.

Regarding the relationship between the second number (r (QLF, ftc) = 0.38, a = 0.01), causality can be explained using the information obtained from this study D'Este and Patel (2007). These authors noted that researchers with a career more consolidated (which can be understood as a measure of qualification) dedicate themselves more to entrepreneurial activities. Thus, one can consider that the qualification of the researcher influences the level of interest by commercial factors when undertaking research.

To explain the causality of the relationship number 3 (rs (yl, mlt) = 0.41, a = 0.005), just go back to the same argument used to explain the relationship found in the number 1 and Zambalde & Tonelli study (2007). As these organs try to publicize the work done at the university inside and outside the institution, it becomes easier communication among different areas of knowledge and fostering cooperation among them. Therefore, it is considered that an ILO (or innovation agency) more developed tends to facilitate the occurrence of multidisciplinary research.

The connection number 4 (rs (mlt, ftc) = 0.40, a = 0.01) is also deceptively simple to explain. According to Kline and Rosenberg (1986), one of the characteristics of innovation is its multidisciplinary character. Moreover Etzkowitz (2000) states that researchers with a more market-oriented are more interested in being able to transform their research into innovations. Thus, it is likely that researchers who focus on business drivers engage in multidisciplinary research more than others simply more focused on expanding the frontiers of knowledge.

Thus, it is assumed that the importance given to commercial factors influencing the propensity of the researcher to join other branches of knowledge, thus realizing more multidisciplinary research.

The relative number 5 (rs (ftc, EVTE) = 0.51, a = 0.0003) is one of the strongest found in the correlation matrix, and also one of the simplest to be explained. Any researcher who values the business factors will seek to combine the technical with economical when choosing which research will be carried forward. Thus it is assumed that the importance given to commercial factors increase the use of feasibility studies and technical economical choice for research to be undertaken.

To explain the relative number 7 (rs (yl, thx) = 0.35, a = 0.02) is necessary to turn our attention again to the duties of an ILO. In addition to facilitating communication among the university and other actors, as has been shown in study and Zambalde & Tonelli (2007), the ILOs or innovation agencies can influence regional development.

This relationship comes to Etzkowitz (2000's study which showed that the university can bring development to the region where it is inserted through other means not related necessarily innovation.

The relative number 8 (rs (lpa, ORP) = 0.35, a = 0.02) has its explanation in the studies of Fujimo & Stal (2005), Costa (2007) and Debackere & Veugelers (2005). According to them, a better targeting of research to be undertaken in universities guides the activities carried out there, thereby making it easier for companies to identify areas more conducive to the realization of cooperation with universities and transparency of these relationships.

But in relation to past links, Costa (2007) and Suziagn & Albuquerque (2008) found in their studies that these links are shaping the way the universities place themselves in future cooperation. Thus, it is assumed that past links with industry begin a cycle to help define the research orientation of universities which in turn helps to increase the number of existing cooperation in this.

The above statement is even clearer because of the relative number 9 (LPR-ORP) is stronger than the relationship number 8 (LPA-ORP). The relationship with the number of current connections with the industrial sector (rs (lpr, orp) = 0.37, a = 0.01) is stronger than the past because of the orientation of research have possibly been influenced by previous collaborations , again confirming the results obtained by Costa (2007) and Suziagn & Albuquerque (2008).

Regarding the relationship between the number of cooperation undertaken in the past and the current number of cooperations (No. 11), causality is very simple, and is the strongest found in the study (rs (lpr, lpa) = 0.81, a = 0.00). Moreover, according to the Kendall coefficient of concordance, this factor appears to be the most important in determining the number of links with industry.

These results corroborate those obtained in the study of Bonzeman and Gaughan (2007), in which the number of connections past appears as the main factor to define the number of current collaborations with industry.

The relative number 13 (rs (mlt, inv) = 0.45, a = 0.001) corroborates the claims made in studies such as Kline and Rosenberg (1986), Miller and Morris (1999), and Etzcowitz Klofsten (2005) and many others, which is evident in the importance of multidisciplinary in determining the number of innovations generated.

The following analyzes, concerning the relations n º 10, 13 and 14 are the most important to try to understand the focus of this work because it will try to explain the relation of cause and effect between the number of innovations and cooperation undertaken with industry.

The relationship number 10 (r (lpa, inv) = 0.54, a = 0.00) is one of the strongest and also the most important in this study, since previous connections with industry are so connected to bonds present . The explanation of this relationship was given by Albuquerque and Póvoa (2005) when these authors argue that the number of links with industry is a growing factor mainly due to innovative capacity of universities.

However, a causal relationship can be explained only indirectly, through one of the critical factors for innovation: the influence of business (FTC). By analyzing this variable, it was expected that there was a relationship between her and the number of links with industry, whether past or present. The reason, as explained in the study of D'Este & Patel (2007), is that focusing more on the market, researchers tend to have higher chances of getting in touch with the industry.

Thus, it is possible to make two assumptions. One is that the number of innovations acts as an intermediary between the number of past links and commercial factors, or the opposite, being an intermediary between the business drivers and the number of past links.

As the connection of the variable INV is much stronger with LPA (rs (inv, lpa) = 0.54, a = 0.00) than with the FTC (rs (FTC inv) = 0.30, a = 0, 04), it is assumed that the number of past links influences the interest by commercial factors indirectly through the number of innovations that a researcher has already produced through their work (paragraph 12).

Thus, it can be considered that the number of innovations, influenced by past contacts with industry (No. 10), increases the importance given to commercial factors (No. 12), which in turn boosts the number of multidisciplinary research (No. 4) culminating in that end innovations (No. 13), forming a closed loop (Figure 2).

In the same way, it can be considered that LPA also influences indirectly through LPR INV, so the link number 14, that is, the number of innovations that generated a researcher may influence the number of calls he has in this sector with industrial (re (inv, lpr) = 0.48, a = 0.001), thanks to the cooperation undertaken in the past.

This cycle begins with past links boosting capacity to innovate which in turn attracts new cooperation which further increases the generation of innovations. Exactly as predicted in the results of the work of Bozeman & Gaughan (2007) and Etzkowitz & Klofsten (2005).

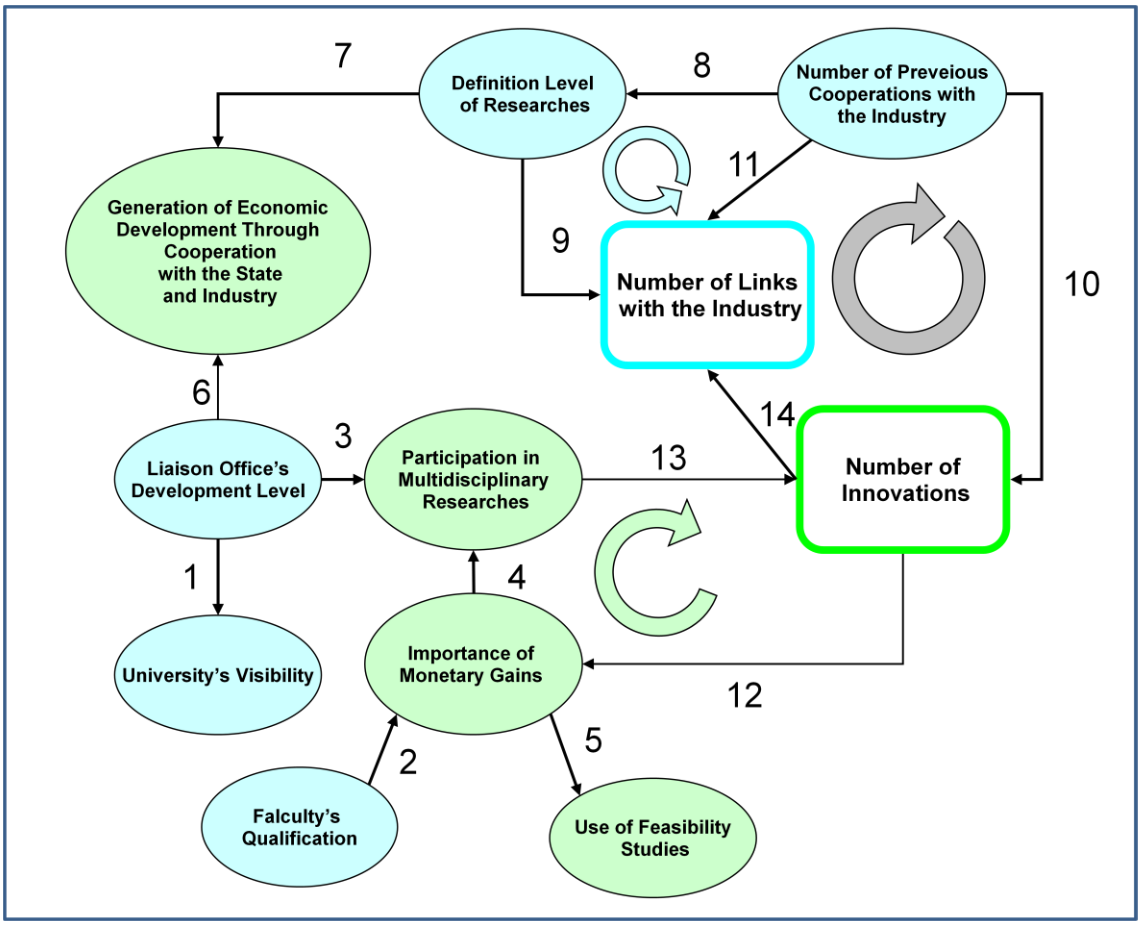

Figure 2: Diagram of cause and effect of the variables

Bozeman & Gaughan (2007) showed that researchers who relate more to the industry are more likely to innovate and to relate back to this sector in the future. Already Etzkowitz & Klofsten (2005) speak of the renewal capacity of the technological paradigm, partly achieved through this cycle, since this study was also taken into account the role of the State.

Already Albuquerque & Póvoa (2005) noticed in their study that past links with the industrial sector enhances the innovative potential of the researchers, who also assists the occurrence of new connections. A good explanation for this phenomenon was given by Costa (2007), in finding that entrepreneurs look for research that can earn profits in the shortest possible time. So for them, researchers that had succeeded in the past in generating innovations through contact with industry would be the most suitable to make new partnerships.

4 FINDINGS AND CONCLUSIONS

This study identified in the literature some of the variables that influence the degree of linkage between universities and industry in general, as well as those that drove the generation of innovations within universities. With this, we sought to identify which of these variables appeared to be the most significant in the context of the engineering courses of public universities of Rio de Janeiro State in Brazil.

To do this analysis, we used techniques from non-parametric statistics, due to the population size of the sample, and not knowing if the population was normally distributed. The Kendall’s W correlation coefficient and the Spearman’s correlation coefficient of rank-order to interpret the data obtained.

The degree of contact with the industrial sector has an effect on the number of innovations done trough university research. However, some variables behave according to studies done in other states, and in different countries. This indicates that contact with the industry tends to improve the innovation process originated in universities; this phenomenon may be a general trend. This highlighted the importance of having a closer relationship between academia and industry. But the results were evidence that academia is still slightly open or is ineffective in this type of relationship, at least when it comes to cooperation in research.

Part of this may be explained by the low level of interest observed in the responses of researchers both to the importance of business factors (average 2.26) and the use of feasibility studies, technical-economical (average 2.83) in performing a research. According Fujimo & Stal (2005) the lack of interest for these factors is one of the major barriers to successful partnerships between universities and businesses.

Moreover, the observed low level of development of the departments responsible for coordinating the links between academia and industry (average of 2.59) also hinders the strengthening of ties between them.

There was also evidence that the regional development has little to do with the innovations generated by universities, as there was no relationship between THX and INV. This corroborates the assertion Klofsten & Etzkowitz (2005) that Latin American universities have not undertake the so-called third mission, *i.e* active participation in regional development mainly through innovations.

The main conclusion of this study is the fact that the number of connections that a researcher had with the industrial sector seems to be the main factor to determine the number of innovations he/she produce. It was shown that the degree of contact that university researchers have with industry shapes the way the university will direct their research in the future.

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