THE UNIVERSITY-INDUSTRY RELATIONSHIP IN BRAZIL: THE IMPACT OF INSTITUTIONS AND SOCIAL CAPITAL IN BRAZILIAN'S SECTORIAL SYSTEMS OF INNOVATION

Ronivaldo Steingraber[♣]
Flávio de Oliveira Gonçalves[⁑]

Abstract – This article examines the relationship between universities and firms in Brazil. This relationship is considered an important tool for innovation, and connects the generation of technological knowledge from the university with the potential to generate economic value in the firm, by developing innovative products. The results reinforce the idea that university-industry relationship in Brazil is still incipient and weak, and concentrated in few industries. It is developed a hierarchical regression model that captures the firm's capabilities and the university's importance in the industrial level to the innovation process in the firm's productivity gains.

Key words: university-industry relationship, innovation, social capital, institutions, knowledge organization, Brazilian industry.

JEL: O31, O32, O33

Subtheme: TH in developing countries

1. INTRODUCTION

This article examines the relationship between universities and firms in Brazil. It is considered an important innovation tool that connects the generation of technological knowledge from the university with the potential of economic value development in the firm through innovative product, process and practices.

This relationship can be considered as formation of social capital, and is highlighted by theories of innovation, as the Schumpeterian, as a complement of the institutions in the process of systemic innovation. In this sense, firms do not have all the innovative capabilities needed, and they need to search for such ones to the success of innovation process. By the side of the university, the capabilities are engaged in research and development of knowledge, but are not dedicated to the economic development of these ideas into products and services by means of innovations in product, process or organizational systems.

This article analyzes the formation of social capital in the university-industry relationship by means of a model of multilevel regression for the Brazilian industrial firms in the year 2005, so far, three sections are presented, out this introduction. Section 2 presents the theories about the contribution of universities in the innovation process by the classic role of the university as a knowledge developer. Section 3 presents the model to be estimated as function of capabilities of the innovator and the industrial impact of the university, through a model of multilevel regression. Section 4 analyzes the results that show a weak and incipient relationship between the university and the Brazilian industry, since it is concentrated only in 1/4 of the industrial sectors.

[♣] Positivo University. Contact: ronistein@swi.com.br
[⁑] Federal University of Paraná.

2. UNIVERSITY IMPORTANCE IN THE INNOVATION PROCESS

The innovation process is analyzed in the Schumpeterian theory as a systemic process. Innovation is not an isolated act of the firm, and it arises from the company's connection with the institutional environment, creating social capital as pointed by Nelson and Nelson (2002). The firm needs to develop skills and competencies to innovate, and all these features are called capabilities, and are the basis of search for technological knowledge in the firm (TEECE ET ALLI, 1997).

The firm alone produces little innovation and small economic value. A systemic innovation comes from forming a network among the social actors that belongs to the generation, dissemination and use of technological knowledge. The firm operates in this network. From this point of view, the knowledge is presented by Nelson and Nelson (2002) as a social technology, and it unites the various social actors who may have different interests.

Regarding the role of institutions in development of technological knowledge, which is the raw material of innovation, it is possible to confirm a particular emphasis on universities. Nelson and Rosenberg (1993) show that the current model of industrial innovation enhances the university as an essential part of the innovation system.

One of the contributing factors of universities to the technological advance is the development of human capital. However, the university's research is an important factor of technological progress in the society. Audretsch et alli (2005) show that the university is a clustering factor of innovations. The formation of technological entrepreneurship is higher around universities. The regional innovation system, according to Cooke et alli (1997), is developed with strong participation of universities. The sectoral system of innovation, according to Malerba (2002), has the university as one of the most important institutions in the innovation process. Other systems of innovation, as the national system of innovation found on Andersen and Lundvall (1997), and technological system, presented in Carlsson and Jacobson (1997), identified the university as one of the key institutional actors in the innovation process too.

It is noticed that the systems of innovation show the relationship between the firms (with their capabilities) and institutions, like a bridge to the formation of innovation. Another feature identified is the appreciation of the university as a key institution in the innovation process. Any outbreak of systemic analysis of innovation in the economy defines the university as a central institutional actor in technology development and generation of innovations.

The finding that in a certain region (or country), for a given economic sector (industry) there is a university this is not a sufficient condition to ensure the development of the innovation process. In addition of the microeconomic conditions (firm’s innovative capabilities), the process of innovation demand an interactive behavior between the institutions and firms, generating and sharing knowledge and supporting the development of innovations.

The focus on the role of the university in the innovation process lies in the fact that it has the capacity to generate and expand innovative capabilities to the firms. Etzkowitz (1998) shows that many firms see the university as a technological competitor, when supports the formation of new enterprises. However, the formation of technological entrepreneurship depends of institutional factors beyond the university's presence on region. Audretsch et alli (2005) show that the technological trajectory must be in the early stage so that the role of universities could be crucial in the process of innovation in small and micro enterprises. Already Colombo and Delmastro (2002) analyze the characteristics of the enterprise, institutions and entrepreneurial firm’s incubator in Italy and conclude that the entrepreneurial profile is crucial in the formation of high-performance technology firms. Briefly, the institutions play an important role in the innovation process, but the innovator must have the capabilities required, and the formation of a network linking the two sides (economic and social) is the basic premise for developing innovations and advancement technological knowledge.

The relevant institutional environment to the relationship between universities and firms also demand a structure that facilitates innovation process. Colyvas et alli (2002) consider property rights as essential for that inventions could be developed in innovative opportunities by the firm. For inventions already widespread the property rights are less important than the new technological inventions, this shows the institutional difference of the product life cycle, where the technologies in the initial phase of expansion can generate a window of opportunity, and this opportunities are better captured by small businesses and new entrepreneurs.[1]

The universities are included, as Schot and Geels (2007) denote, in socio-technical systems that make up the rules of how to produce, use and regulate the technology. Other knowledge centers such as hospitals, industries and government laboratories are also in the socio-technical system; however, as shown by Godin and Gingras (2000), the other centers of knowledge are usually linked to universities that remain as the center of the knowledge production system.

The university works as a center of knowledge development. This accumulated knowledge is absorbed when firms and other institutions make up social capital with the university by developing a network of diffusion of technological knowledge. This is reason why Nelson and Nelson (2002) call the technological knowledge, when it becomes the basic input for innovation, as a "social technology", and it is developed only when a connection is formed by social and economic factors. It is observed that the relationship between university-industry and other relations between the university and social actors to the development of technological expertise can be called of building of social capital for innovation[2].

As knowledge has two possible classifications according to their diffusion, the role of universities changed according to the way of knowledge is presented. Knowledge can be codified or tacit. Codified knowledge is presented as a language feature. Any individual with training in language decoding can understand and absorb the knowledge in question. Traditionally, university excels in human capital formation in relation to codified knowledge, and universities' research is encoded, requiring capabilities to understand the accumulated knowledge related with coded information.

Tacit knowledge is related to the knowledge accumulated by experience in the process of innovation[3.] The tacit nature of knowledge, as well as encryption, requires knowledge accumulated. However, tacit knowledge is learned in various ways. The learning in the process of innovation assumes many forms. For Cohen and Levinthal (1990) the learning is presented in the form of absorptive capacity of knowledge that depends on the microeconomic characteristics of the firm. For Siverberg and Varspagen (1994) learning is a collective phenomenon, so dependent on social and related institutions. For MacKinnon et alli (2002) learning is collective and limited by region, the authors show that the production systems and local innovation (as the *milieu)* are sources of institutionalized collective learning.

In general, the learning process in Schumpeterian literature is a social phenomenon. It is born of the relationship of the firm's capabilities with institutions in the social, economic and geographic environment.

The university has been characterized throughout the twentieth century by production of codified knowledge and little production of tacit knowledge. Antonelli (2008) identifies two systems of knowledge generation in universities. The first is the *open science,* characterized by codified knowledge and open to the whole society. The second system is the "academic administration of creativity," characterized by the interaction between universities and institutions with industry to expand technological and scientific knowledge, and produce innovations in this system, besides the codified knowledge, the university stands by the generation of tacit knowledge to support the innovation process in the economy.

The system of knowledge generation by the academic administration of creativity does not have coverage all universities. Feldman (2003) comments the origin of the new academic system, by the author, it was introduced after the Second World War in some American universities, but currently is not used in all universities. The author argues that the new system demands a different

---

[1] Colyvas et alli (2002) show the exponential growth of the innovations after the Bahy-Dole Act in the universities. They believe that the Innovation Offices could guarantee the property rights of the universities' knowledge. Panagopoulos (2003) analyses the legal instruments of protection in the university-industry relation.

[2] See Putnam (2001), Coleman (1988), and Knack and Keefer (1997) to the definition of social capital social, and Nelson and Sampat (2001) to importance of the social capital in the economic process of innovation.

[3] Archibugi and Pietrobelli (2003) argument that the major of innovations are changing of embodied technology to disembodied technology (tacit) in the form of ideas, and expertise protected by property rights.

institutional structure, based on the construction of offices of technology transfer. These offices operate as units of the university's relationship with the other actors.

The Innovation Offices guarantees the property right of the university's knowledge in relation to other stakeholders. Through the university's office provides economic resources to the knowledge generated by becoming an official supplier of knowledge for the firm's innovation process. This knowledge is in the form of codified knowledge such as patents and other forms of assurance that knowledge belongs to the university. Knowledge also may be in the form of tacit knowledge. This is presented in the form of training, advising and consulting that university can provide through its physical, human and social capital available to actors interested in innovating.

In view of Feldman (2003) universities engaged in the new model of technology transfer, which must be involved with local economic development and entrepreneurship, especially with the start-ups firms.

Antonelli (2008) compares the two academic systems of knowledge generation. The author argues that the university administration model of creativity has become a provider of knowledge (in the economic sense) for the innovation process. While the old system depended on public funds to finance technological development, the new search system depends of the formation of social partnerships (mainly companies) to secure resources to support science and technology. These new social partnerships in the new system include businesses, capital venture, consortium of knowledge generation and the public sector. Among these partnerships, it is highlight the technological entrepreneurship, advocated by Feldman (2003) and Audretsch et alli (2005).

The question that arises is why the *open science* model of knowledge, which brought the firms (with codified knowledge's absorptive capabilities) around universities, has been replaced by the administration model of creativity, where the university establishes partnerships and 'sells' knowledge to firms?

Dasgupta and David (2002) show that the system based on *open science* has codified knowledge, institutions and social norms that do not take account of resource allocation in the long run for a knowledge society. The answer is not in reorganization of the university, but the structural change of society in relation of knowledge that is replaced by strategic value in business.

One of the consequences of the new model is presented by Mansfield (1998). The author shows that the time between an academic research and the launch of innovative product in the industry is diminishing[4]. Since technological development is the key to the current competition among firms, the absorption of knowledge to innovate is crucial, and the formation of partnerships (social capital) at the university is one of the main sources of knowledge in society. On the other words, if knowledge offered by the university is tacit, the learning time is shorter.

Antonelli (2008) considers the economic advantage of university-industry partnership in relation to lower costs of the university and the business spending on research and laboratories. The author also highlights the problem of risk involved in the research enterprise. The elevated risk makes impossible the determination of the money's return invested by the firm, and the cost of monitoring activities undertaken. This monitoring leads to a problem of principal-agent type. Already as the universities have more human capital, its control and monitoring can pursuit better results.

For Antonelli (2008) the university has become an institution, with structure and hierarchy in the development of specialized technological knowledge. The university administration in the model of creativity is not limited to manage technological knowledge. The relationship between the university and the tacit knowledge is greater. Thus, the university is also involved with the process of innovation, and not only with the generation of codified knowledge.

The relationship between universities and firms is established by the share in the same on knowledge market (such as patents and other means of coded knowledge) and teaching-research relationship. The role of the university goes beyond education and human capital formation. Contracts ensure that knowledge, research and intellectual property rights are not exclusive to the innovative firm that has established a relationship with the university, thus, the university can to serve more firms with the same knowledge generated, becoming a source of solutions for knowledge and innovation.

[4] For the author: "(...) the new products introduced by large firms may be based to a greater degree on short-reach, more applied academic research than in earlier days, relative to small firms." (Mansfield, 1998: 775).

Increased participation of tacit knowledge in universities, through their physical structure that few companies possess, their high human capital (hence the emphasis on undergraduate research), and extensive network (social capital), ensures that the university now become a center of excellence in the innovation process.

The university develops new institutions (internal and external) with the intention to establish the sale of codified and tacit knowledge in the market, establishing itself as an economic agent. However, the relationship between universities and firms takes place in two ways: a) microeconomic b) institutional.

From the microeconomic point of view the university-industry relationship demands the possession of necessary capabilities for starting the innovation process. The mission of the university may be in providing these capabilities for interested firms to innovate, through human capital, advice and consultancy. It is perceived that the knowledge that the university provides can be in the form of codified and tacit, however, innovation process requires more tacit knowledge. The university is a supplier of codified knowledge available in the form of scientific papers, and patents to the supply of skilled labor with embedded knowledge. In addition it can provide contracts and licenses that show how to make the development of products and processes. The university dominates and accumulates the art of innovation and goes beyond the accumulating process of theoretical knowledge.

From the institutional point of view the university also offers a new way of understanding the innovation process. A new institutional network is formed around the university. The university needs to establish a contact with the regional actors. It is perceived that the institutional role of the university meets the definition of public policies for the evolution of knowledge, and absorption of the same in the form of innovations by economic agents. From this point of view the university should establish a network of social capital with the demands of region's social and economic actors to innovate.

Mesoeconomics and regional factors determine the process of innovation in firms and are shaped by the presence of the university, and the intensity and extent of the capital formed with it. The university's definition of specialized knowledge areas may to explain the industries differences into the innovation process. These differences in intensity around universities in different regions set the geographical boundaries for innovation. The intensity of university-industry network and possessing the innovative capabilities define the differences between firms.

The hypothesis that the university is an important factor for absorption of knowledge in the Brazilian industrial firms is tested on the study of Negri (2006). The author shows that the more innovative Brazilian industrial firms have specific capabilities, as human capital and the formation of partnerships with universities to innovate.

The role of the university under the institutional point of view, influencing innovation in certain industries with the use social capabilities has not been tested. This hypothesis is presented in the model that analyzes the impact of the university on the productivity of Brazilian industry, developed in the next section.

3. MODEL

The presence of universities is crucial in the process of firm's innovation. The model examines empirically the total factor productivity (TFP) on the Brazilian industrial firms in year 2005 according to the firm's capabilities and the restriction of industrial cooperation with universities, research centers and tests.

The estimation is performed by a hierarchical regression model. See Bryk and Raudenbush (2002) for the analysis of multilevel regression models. The equation of the first level that explains the company's TFP by their innovative capabilities, according to the model presented in Steingraber (2009) can be defined as[5]:

[5] The original model develop in the Doctoral Thesis was building with a research project at the Instituto de Pesquisa Econômica Aplicada (IPEA) – Applied Economic Research Institute - and Observatório da Inovação (USP) – Innovation Observer (São Paulo University) - with the micro data from IBGE. The estimated model and its theoretical discussion, and discursive statistics (that show productivity differences between firms and

$$TFP_{ij} = \alpha_0 + \alpha_1 PO3_{ij} + \alpha_2 Rme_{ij} + \alpha_3 TEme_{ij} + \alpha_4 MOino_{ij} + \alpha_5 NPedidos_{ij} + \alpha_6 Share_{ij} + \alpha_7 Contratos_{ij} + \alpha_8 VX_{ij} + \alpha_9 VI_{ij} + e_{ij} \quad (1)$$

Where equation (1) shows the TFP_{ij} (Total Factor Productivity) of firm *i* in sector *j* estimated by the percentage of workers with third-degree ($PO3_{ij}$), the average worker income (Rme_{ij}), the average time for study of workers ($TEme_{ij}$), innovative labor ($MOino_{ij}$), the number of patents requests ($NPedidos_{ij}$), market share ($Share_{ij}$), the number of contracts ($Contratos_{ij}$), the export value (VX_{ij}) and the import value (VI_{ij}). The estimated equation also has an intercept (α_0) and noise (e_{ij}).

The variable percentage of workers with third level is calculated by the percentage of workers (PO - employees) with a college degree at function of the total number of employees. The average worker income is the average value in Reais (R$) of all employees of the firm, as well as the average time of study of workers. The labor dedicated to innovations considered is the percentage of occupations involved in R&D&I, as engineers and professionals dedicated to R&D, it is constructed by the IPEA's statistical team with definition of occupations of the Brazilian Labor Department. The number of employees is presented as the number of contracts, and the firm's share is calculated by the firm's participation in total industry's employment. All these variables belong to RAIS[6] at the year 2005.

The variable number of requests is related to the number of patent applications filed at the INPI[7] in year 2005 and two years before (2003 and 2004) for firm *i* in sector *j.*

The export and import values belong to the base of SECEX[8] and concerns in dollar value in 2005.

The base PIA[9] contributed to the definition of three variables. The share of inputs in the international firms was calculated by the value of the exports (converted at average exchange rate in 2005[10] divided by firm's average income (in dollars). The variable turnover was calculated as the capital stock in machinery and equipment in 2005 in relation to the total stock of capital. The capital stock in the PIA is determined by the sum of assets (machinery and equipment, facilities, and other assets loss in value - depreciation). These two variables of the PIA were not statistically significant and were dropped out from the model. In this sense, we chose to removal off the variable share from the estimative (which is statistically significant), whereas the share of employment was also significant, we chose to standardize the variable with the base RAIS. Thus, PIA has not presented any variable in the definition of TFP of firm *i* in industry *j*.

The second level equation considers the cooperation between firms and universities, test and research centers[11]. This variable involves institutions of generating codified and tacit technological knowledge. Its construction is sectoral (industry) and its values reflect the differences between industries in the firm's relationship with the institutions. The second level's importance is relates to the formation of social capital at the industry level as a determinant to explain the firm's productivity according to its innovative capabilities in the first level.

With the two levels, the model captures the impact of industrial differences in the formation of knowledge in the research centers and universities, reflecting different technological trajectories and different levels of development of social capital and institutions into the industry. The firm's productivity explained by its capabilities is related to these industrial differences, therefore,

---

industries at the first level, justifying the use of hierarchical estimation) are not showed in this paper. The completed study can be observed in: http://dspace.c3sl.ufpr.br:8080/dspace/bitstream/1884/22570/1/Steingraber,%20Ronivaldo.pdf

[6] Annual Report of Social Indicators of Labor Department.

[7] National Property Rights Institute.

[8] External Trade Office.

[9] Annual Industrial Report from Brazilian Institute of Geography and Statistics (IBGE).

[10] This value is R$ 2,41 = 1 US$.

[11] It is a dummy variable with value 1 if firm answer in the fields 1 and 2 (high and medium) in the PINTEC's questions 115-117, and 0 if the answer is 3 or 4 (small or not relevant) in the same questions.

technological developments and industry are presented together, as the concept of the Sectoral Innovation System of Malerba (2002).

Introducing the control variable in the second level, the parameters identified in equation (1) will be explained by differences in industry related educational institutions. The second level is now defined as:

$$\boldsymbol{\alpha}_{sij} = \beta_0 + \beta_1 U_j + e_j \quad (2)$$

Where $\boldsymbol{\alpha}_{sij}$ is the vector of *s* estimated parameters plus the independent term of equation (1). Each parameter of equation (1) is estimated on the basis of a linear coefficient (β_0) which captures the average of the Brazilian industry in the firm's importance of the universities, and test and research centers to innovate (U_j), for each industry *j* in the year 2005, and a noise (e_j) which is a random term that captures the industry differences in the model.

Substituting (2) in (1) is obtained the two-level model in a single equation to be estimated.

$$TFP_{ij} = (\beta_0 + \beta_1 U_j + e_j) + (\beta_0 + \beta_1 U_j + e_j)PO3_{ij} + (\beta_0 + \beta_1 U_j + e_j)Rme_{ij} + (\beta_0 + \beta_1 U_j + e_j)TEme_{ij} + (\beta_0 + \beta_1 U_j + e_j)MOino_{ij} + (\beta_0 + \beta_1 U_j + e_j)NPedidos_{ij} + (\beta_0 + \beta_1 U_j + e_j)Share_{ij} + (\beta_0 + \beta_1 U_j + e_j)Contratos_{ij} + (\beta_0 + \beta_1 U_j + e_j)VX_{ij} + (\beta_0 + \beta_1 U_j + e_j)VI_{ij} + e_{ij} \quad (3)$$

Rearranging the elements of (3), we have:

$$PTF_{ij} = \beta_0 + \beta_0\left(PO3_{ij} + Rme_{ij} + TEme_{ij} + MOino_{ij} + NPedidos_{ij} + Share_{ij} + Contratos_{ij} + VX_{ij} + VI_{ij}\right) + \beta_1 U_j + \beta_1 U_j\left(PO3_{ij} + Rme_{ij} + TEme_{ij} + MOino_{ij} + NPedidos_{ij} + Share_{ij} + Contratos_{ij} + VX_{ij} + VI_{ij}\right) + e_j\left(PO3_{ij} + Rme_{ij} + TEme_{ij} + MOino_{ij} + NPedidos_{ij} + Share_{ij} + Contratos_{ij} + VX_{ij} + VI_{ij}\right) + e_j + e_{ij} \quad (4)$$

Equation (3) shows that TFP depends on three clusters. The first is the set of firm's characteristics related to the parameter β_0. This parameter represents the industry average's total factor productivity, because the variables used are centralized[12]. The second group belongs to the coefficient β_1, it adds the firm's characteristics with the industry variable (by multiplication). The results of this group show the sensitivity of firm's TFP and its capabilities to the industry importance of the universities in the innovation process. The last group shows the random effects of capabilities around the industries.

The results of equation (4) estimated are presented and analyzed in the next section.

4. RESULTS

The estimated fixed effects of equation (4) show the contribution of the firm's competencies and the importance of these skills in the university-industry relation explaining the TFP of each firm by industry. The overall result is presented in Table 1 below.

[12] The variables interpretation in the hierarchical regression is particular in function of the centralized mean utilized. The sign positive shows that variable is contributing with the firm's TFP above the medium. Just the sign negative shows that the variable is contributing less with the firm's TFP.

Table 1: FIRM'S TFP EXPLAINED BY ITS CAPABILITIES AND UNIVERSITY-INDUSTRY RELATIONSHIP IN THE YEAR 2005

VARIABLE	TEST t	P
Intercept	-5256034	***
PO3 – percentage of worker with higher education	-133341	***
Rme – worker's average income	10014	***
TEme – worker's average study	Ns	
MOivov – innovative labor	419647	***
NPedidos – patents	442094	***
Share	1.04 E+13	***
Contratos – number of employess	Ns	
VX – export value	-0.7814	***
VI – import value	-0.3374	***
University	2.01 E+12	**
PO3*University	Ns	
Rme*University	-196398	***
TEme*University	21314413	***
MOinov*University	10467364	***
NPedidos*University	-388726	**
Share*University	-2.52 E+10	***
Contratos*University	300911	***
VX*University	50469	***
VI*University	141035	***
-2 Res Log Likelihood	991124.4	
AIC (smaller is better)	991128.4	
AICC (smaller is better)	991128.4	
BIC (smaller is better)	991133.8	

Source: Data calculated by the author with micro data from the IBGE based on equation (4).
*** P <0.001, ** 0001 <ρ <0.05; * 00:05 <ρ <0.1

The data in Table 1 show that the Brazilian industrial firms show productivity gains with the innovative labor, patents and the labor's income. The increased participation of companies in the market (share) is almost zero, but also positive. Other variables that showed minor contribution on productivity (negative sign) are exports, imports and labor force with third degree. Schooling time and number of employees (contracts) were not statistically significant in explaining the company's productivity.

Regarding the industrial behavior of firms to the importance of the university's explanation of productivity, it is noticed that the variable itself is near zero, but with sign negative (below average). Other variables that have sectorally productivity gains below average depending on the importance of the university are: labor income, patents and the participation of firms at market. Schooling, innovative labor, the number of workers and foreign trade (exports and imports) contributes to productivity gains more than average in industries depending on the importance of the university in the innovation process into firms.

Some differences between microeconomic behavior and industry can be identified in the estimated results of the importance of universities in explaining the productivity of firms.

The first difference is the role of foreign trade. In firms, exports and imports have an impact below the average (minus sign), already in the industry the impact is positive in the presence of universities (above average). Thus, differences in foreign trade are more visible among the economic sectors. Studies such as Negri and Salerno (2005) and Negri and Araujo (2007) show that the impact of foreign trade is positive in the innovative Brazilian industrial firms, however, the results here show that the estimated impact of foreign trade explains less the productivity of individual firms and more gains of productivity in industry, where industries with closer cooperation with the universities have a greater impact on foreign trade in productivity.

The second difference is in labor income, number of patents and the market participation of firms. These variables generate productivity gains above average in firms, and contribute to the productivity below the average at industry. In this sense, we find that these variables are more important in microeconomic sphere than in the industry in explaining the gains in productivity. Higher wages working in companies is a strategy to attract better human capital that generates improved productivity, the relationship between the industries with the university is not dominated by sectors with higher incomes, which shows that the orientation of the university does not follow the same business logic, as the commercial orientation. The patents show the development of factors for innovation in the firm in the form of property rights that can be transformed into future innovations, and productivity gains, in the industry the importance of the university is not guided by the generation of patents, which shows that the Brazilian university has not developed the creative management of knowledge, and is driven by the supply of human capital and knowledge, in the *open science* type of orientation, with little protection of knowledge generated. Market concentration shows that firms with market power experience greater productivity gains, however, the importance of university-industry in this relationship is not so important, which shows that big firm's with market power are independent against the importance university in their strategies to gain productivity.

The third difference is the firm's size. To the firm, the size was not statistically significant in explaining productivity gains, however, in industry the importance of the university is positively related to firm's size. Thus, industries with larger firms tend to have higher probability that the relationship with the university generate productivity gains in firms above average. Another explanation lies in presence of fixed costs of training, infrastructure, and availability of skilled labor to firms interact with the university, creating social capital and benefiting from this relationship, these factors are sectorial, and theirs availability in a university generate few spillover effects to other industries. This result shows the limit of the knowledge spillover in university-industry relation, where the firm's size in the industry determines the dynamics of the relationship with the university, by building relationship capabilities with the university, as the model of Bercovitz and Feldman (2006) appointed. The economic literature of technological complexity, and Sectorial Systems of Innovation explain the limitation of spillovers between industries[13], however, the results show that this limit can also be dependent of the capabilities and industry structure between firms and universities, where mature industries with larger firms establish greater links with universities. Moreover, new sectors, are limits on the formation of social capital with the university, verified the absence of quality labor and infrastructure for small startup companies.

Industries with larger firms have higher productivity gains in reaching out to universities; however, with increasing market share gains in these industries, they have the productivity gains below average due to lower dependency of universities. Thus, it appears a cycle of market concentration on the importance of the university in the productivity gains in the form of a Kuznets curve: larger firms are closer to the universities and generate higher productivity gains, however, with increasing market power (with large size) in an industry, they become less reliant on the university, and more active on their own strategies for innovation and productivity gains.

There are not only differences perceived between the firms and industry. Human capital has positive impacts on the firm (innovative labor) and industry (education and innovative labor). The negative highlight was variable participation of labor with third grade with below-average value in the firm and not significant in the industry. This shows that the firms with high rates of labor with schooling do not develop a sufficient condition to generate productivity gains, for this, human capital should be instructed to be innovative.

Considering the random effects in the sectors, Table 2 shows the significant industries. The industrial classification used is the CNAE 1.0 with 109 sectors[14].

[13] This explains why the technological trajectory belongs to the industry.
[14] Classificação Nacional de Atividades Econômicas or National Classification of Economic Activities.

Table 2: RANDOM EFFECTS OF FIRM'S CAPABILITIES ON THE IMPORTANCE OF UNIVERSITY IN INDUSTRIAL SECTORS IN THE YEAR 2005

Industry	**Education to R&D&I**	**ρ**
Extraction of coal	+	***
Service related to the extraction of oil and natural gas	+	**
Extraction of iron ore	+	**
Extraction of stone, sand and clay	-	*
Processing, preservation and canning of fruits, vegetables and other vegetables	-	**
Manufacture of sugar refining	-	**
Manufacture of beverages	-	**
Manufacture of tobacco	+	***
Shoemaking	-	*
Manufacture of wood, cork and twisted material	+	**
Production of written materials	+	**
Manufacture of petroleum products	-	**
Manufacture of inorganic chemicals	+	***
Manufacture of pharmaceuticals	-	**
Manufacture of pesticides	-	**
Manufacture of soap and detergents, cleaning products and toiletries	-	**
Manufacture of rubber	-	**
Foundry	-	**
Manufacture of motors, pumps, compressors and transmission equipment	-	*
Manufacture of tractors and machinery and equipment for agriculture, poultry and livestock products	-	***
Manufacture of machinery and equipment for use in mining and construction	+	**
Manufacture of machinery and equipment, electronic systems for data processing	-	**
Manufacture of electrical equipment for vehicles	-	*
Manufacture of basic electronic	-	*
Manufacture of equipment and telephony equipment and radio and television transmitters and radio	-	***
Maintenance and repair of equipment and telephony equipment and radio and television transmitters and radio	-	***
Manufacture of cars, vans and utilities	+	***
Construction, assembly and repair of aircraft	-	***
Manufacture of miscellaneous products	-	**
Significant sectors	29	
Positive	9	
Negative	20	

Source: The author with micro-data from the IBGE based on equation (4).
*** P <0.001, ** 0001 <ρ <0.05; * 00:05 <ρ <0.1

The data in Table 2 show that 29 sectors are statistically significant with presence of universities (and other research centers, tests and essays) in determining firm's TFP outside the industry's average, which represents 26.60% of Brazilian industries. Thus, the remaining 73.40% of Brazilian industries have increased productivity of their firms about the importance of the university in the average.

The deviation from the average can be grouped into two groups: those industries with productivity gains above and below the average, with positive and negative sign respectively. Industries with positive sign totaling nine, since firms with negative sign totaling twenty, representing respectively 8.26 and 18.35% of Brazilian industries analyzed.

The industries with productivity gains above average depending on the university's importance are: extraction of coal, oil and minerals (iron), manufacture of tobacco products, wood products, recorded materials, inorganic chemicals, machinery and equipment for the construction industry and the automotive industry.

The industries with productivity gains below average depending on the university's importance are: extraction of stone, sand and clay, preserved food production, refining sugar, beverages, footwear, petroleum, pharmaceuticals, agrochemicals, products cleaning, rubber, castings, engines, tractors, machinery and equipment for electronics, electrical materials (for vehicles) and electronics, telephony equipment, miscellaneous items and aerospace industry.

The negative sign in these sectors indicates the lack of social capital that links firms with the expertise of the university, leading to lower impact of the university in firm's productivity. The estimate shows that technologically important industries, like pharmaceuticals, aerospace, electronic and telephonic equipment, depend less on the university in Brazil. This result shows that the idea of technologically advanced industries is not well adapted to Brazilian reality, such as the Pavitt's taxonomy, because the productivity's gains are associated to the firm's capabilities more than the university's importance at the industry.

5. CONCLUSION

This article considered the impact of university-industry relationship to systemic innovation process. In this sense, the model estimated the firm's productivity according to their capabilities to innovate and importance of the university at industry.

The estimated results show differences between the capabilities to innovate in firms and the importance of university at the industrial level in relation to productivity gains. These differences indicate an important contribution of size of business and trade in industries are greater with proximity to the universities; and income, patents and market concentration in the firm level as explanations for the productivity gain.

It was identified that twenty-nine sectors of Brazilian industrial firms had productivity gains than the average Brazilian manufacturing firms in 2005. Of these, only nine industries showed gains in productivity above the average in manufacturing, and other twenty sectors showed gains below the overall average productivity of Brazilian industry, where technologically advanced industries (at the developed countries) were among the industries with lower productivity gain depending on proximity to the university in Brazil in 2005.

This result reinforces the idea that university-industry relationship in Brazil is still incipient and weak, and needs to walk a long way to assert itself as an instrument to support innovation. Another achievement is the lack of relationship between the Brazilian industries framework and taxonomy of Pavitt (1984), where, clearly low-tech industries have appointed productivity gains with greater proximity to the university at the expense of technologically advanced industries, which reinforces the idea that Brazilian industrial dynamics and its relationship with the university are difference at the Pavitt's results.

Despite the results obtained are not much encouraging, we encouraged making further studies and more researches on the institutional environment dedicated to the university-industry relationship. The lack of specific regulations increases the likelihood of opportunism and reduces the number of partnerships between universities and the private sector, and the lack of institutions (such as offices of innovation, and technology and patents transfer) to hold the links between universities and firms. Finally, the role of government, not verified in this study, may be an important success factor of this relationship, and the missing link in the development of innovation in Brazilian industry.

REFERENCES

ACS, ZJ; AUDRETSCH, DB; FELDMAN, MP (1991). Real effects of academic research: comment. The American Economic Review, volume 82, number 1, p.363-367.

ACS, ZJ; AUDRETSCH, DB; FELDMAN, MP (1994). R&D spillovers and recipient firm size. The Review of Economics and Statistics, volume 76, number 2, p. 336-340.

ANDERSEN, ES; LUNDVALL, BA (1997). National innovation systems and the dynamics of the division of labor. In: EDQUIST, C. Systems of innovation: technologies, institutions, and organizations. New York: Routledge, p. 242-265.

ANTONELLI, C (2008). The new economics of the university: a knowledge governance approach. Journal of Technology Transfer, volume 33, p. 1-22.

ARCHIBUGI, D; PIETROBELLI, C (2003). The globalization of technology and its implications for developing countries: windows of opportunity or futher burden? Technological Forecasting and Social Change, volume 70, p. 861-883.

AUDRETSCH, DB; LEHMANN, EE; WARNING, S (2005). University spillovers and new firm localion. Research Policy, volume 34, p. 1113-1122.

BERCOVITZ, J; FELDMAN, M (2006). Entrepreneurial universities and technology transfer: a conceptual framework for understanding knowledge-base economic development. Journal of Technology Transfer, volume 31, p. 175-188.

CARLSSON, B; JACOBSSON, S (1997). Diversity creation and technological systems: a technology policy perspective. In: EDQUIST, C. Systems of innovation: technologies, institutions, and organizations. New York: Routledge, p. 266-294.

COHEN, W; LEVINTHAL, DA (1990). Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly, volume 35, number 1, p. 128-152.

COLEMAN, JS (1988). Social capital in the creation of human capital. The American Journal of Socialogy, volume 94 – Supplement: Organizations and Institutions: sociological and economic approaches to the analysis of social structure, p. S95-S120.

COLOMBO, MG; DELMASTRO, M (2002). How effective are technology incubators? Evidence from Italy. Research Policy, volume 31, p. 1103-1122.

COLYVAS, J; CROW, M; GELIJNS, A; MAZZOLENI, R; NELSON, RR; ROSENBERG, N; SAMPAT, BN (2002). How do university inventions get into practice? Management Science, volume 48, number 1, p. 61-72.

COOKE, P; URANGA, MG; ETXEBARRIA, G (1997). Regional innovation system: institutional and organizational dimensions. Research Policy, volume 26, issue 4-5, p. 475-491.

DASGUPTA, P; DAVID, PA (2002). Toward a new economics of science. In: MIROWSKI, P; SENT, EM. Science bought and sold: essays in the economics of science. Chicago: Chicago University, p. 219-248.

ETZKOWITZ, H (1998). The norms of entrepreneurial science: cognitive effects of the new university-industry linkages. Research Policy, volume 27, p. 823-833.

ETZKOWITZ, H; WEBSTER, A; GEBHERDT, C; TERRA, BRC (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. Research Policy, volume 29, p. 313-330.

FELDMAN, MP (2003). Entrepreneurship and American research universities. In HART, DM. The emergence of entrepreneurship policy: governance, start-ups, and growth in the U.S. knowledge economy. Cambridge: Cambridge, p. 92-112.

FELDMAN, M; AUDRETSCH, DB (1999). Innovation in cities: science-based diversity, specialization and localized competition. European Economic Review, volume 43, p. 409-429.

FELDMAN, M; FRANCIS, JL (2004). Homegrown solutions: fostering clusters formation. Economic Development Quarterly, volume 18, number 2, p. 127-137.

GODIN, G, GINGRAS, Y (2000). The place of universities in the system of knowledge production. Research Policy, volume 29, p. 273-278.

JONES, CI; WILLIAMS, JC (1998). Measuring the social return of P&D. Quarterly Journal of Economics, volume 113, number 4, p.1119-1135.

KNACK, S; KEEFER, P (1997). Does social capital have an economic payoff? A cross-country investigators. The Quarterly Journal of Economics, volume 112, number 4, p. 1251-1288.

KREMER, M. Patent layouts: a mechanism for encouraging innovation. The Quarterly Journal of Economics, volume 113, number 4, p. 1137-1167, 1998.

LINK, AN; SCOTT, JT (2003). U.S. science parks: the diffusion of an innovation and its effects on the academic missions of universities. International Journal of Industrial Organization, volume 21, p. 1323-1356.

MACKINNON, D; CUMBERS, A; CHAPMAN, K (2002). Learning, innovation and regional development: a critical appraisal of recent debates. Progress in Human Geography, volume 26, number 3, p. 293-311.

MALERBA, F (2002). Sectoral systems of innovation and production. Research Policy, volume 31, p. 247-264.

MANSFIELD, E (1998). Academic research and industrial innovation: an update of empirical findings. Research Policy, volume 26, p. 773-776.

NEGRI, F de (2006). Determinantes da capacidade de absorção das firmas brasileiras: qual a influência do perfil da mão-de-obra? In: NEGRI, JA de; NEGRI, F de; COELHO, D. Tecnologia, exportação e emprego. Brasília: IPEA, p. 101-122.

NEGRI, JA de; SALERMO, MS (2005). Inovações, padrões tecnológicos e desempenho das firmas industriais brasileiras. Brasília: IPEA.

NEGRI, JA de; ARAÚJO, BCPO de. (2007). As empresas brasileiras e o comércio internacional. Brasília: IPEA.

NELSON, RR; ROSEMBERG, N (1993). Technical innovation and national systems. In: NELSON, RR. National innovation systems: a comparative analysis. Oxford: Oxford University, p. 3-21.

NELSON, RR; SAMPAT, BN (2001). Making sense of institutions as a factor shaping economic performance. Journal of Economic Behavior & Organization, volume 44, p. 31-54.

NELSON, RR; NELSON, K (2002). Technology, institutions, and innovation system. Research Policy, volume 31, p.265-272.

PANAGOPOULOS, A (2003). Understanding when universities and forms form RJVs: the importance of intellectual property protection. International Journal of Industrial Organization, volume 21, p. 1411-1433.

PAVITT, K (1984). Sectoral patterns of technical change: towards a taxionomy and a theory. Research Policy, volume 13, p.343-373.

PUTNAM, R (2001). Social capital: measurement and consequences. Paris: OECD.

RAUDENBUSH, SW; BRYK, AS (2002). Hierarchical linear models: application and data analysis methods. London: Sage.

SANTOS, F; CROCCO, M; JAYME JR, F (2007). Knowledge externalities and growth in peripheral regions. In: ARESTIS, P; BADDELEY, M; MCCOMBIE, JSL. Economic growth: new direction in theory and policy. Cheltenham: Edward Elgar, p. 223-237.

SCHOT, J; GEELS, FW (2007). Niches in evolutionary theories of technical change: a critical survey of the literature. Journal of Evolutionary Economy, volume 17, p. 605-622.

SCOTT, AJ (2006). Entrepreneurship, innovation and industrial development: geography and the creative field revisited. Small Business Economics, volume 26, p. 1-24.

SILVERBERG, G; VERSPAGEN, B (1994). Collective learning, innovation and growth in a boundedly rational, evolutionary world. Journal of Evolutionary Economics, volume 4, p. 207-226.

TEECE, DJ; PISANO, G; SHUEN, A (1997). Dynamic capabilities and strategic management. Strategic Management Journal, volume 18:7, p. 509-533.