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Sonia K Guimaraes,

Professor,
Federal University of Rio Grande do Sul, Brazil
E-mail: sonia.guimaraes121@gmail.com

Pathways to technological catching up: Relationship University-Business Relations in Brazil

Insofar as knowledge and innovation are considered key to economic growth, universities have been called to collaborate with the productive sector in order to contribute to transform scientific knowledge into technological development, aiming at the development of the companies' innovative capacity. In the case of countries like Brazil, the university-company relationship becomes still more important, due to the companies' low capacity to absorb the knowledge to produce higher level innovations. The paper presents preliminary results of a research in process that investigates university-firms relationships considering eight Brazilian universities located in the south and southeast regions of the country that are characterized by the presence of technological parks and incubators acknowledged as having satisfactory performance. The preliminary data analysis indicates an increasing number of research groups collaborating with companies, in all fields. However, despite the increase in the numbers of research groups maintaining external interactions, the data suggest that the impact of those relationships on the economic sector innovative performance would be not significant. The article main conclusion is that state incentives through laws and other public measures cannot, by themselves, overcome unfavorable features that are present in society.

Keywords: Brazil — innovation – technological catching up – university-industry relations.

Introduction

This paper is part of a research project in progress that deals with the university – enterprises relationship. Companies becomes increasingly dependent on science-based production and services, since scientific knowledge becomes the true raw material and the central source for wealth creation, on which depends economic growth and a solution for societies' current problems – as global warming, food security, population aging, among others. (DEIACO et al., 2012; NOWOTNY et al., 2003). The complexity, costs and risks of research activities and the short life cycle of an innovation force companies to seek external collaborations. The university have been pressured to adapt their organizational structures, skills and strategies breaking away from the Humboldt model tradition – centered on the rigid separation between academia and market interests – also due to the reduction of public resources per researcher, contributing for the universities to accept partnerships with the productive sector. The interaction between the productive sector and the university is considered even more necessary in developing countries, for that collaboration can contribute to improve the companies' capacity in order to carry out the process of catching up.

The links between the university and business are not new: the University of Venice, in the 15th century, created a discipline of mathematics oriented to navigation relying on the economic impacts that would follow; in the 19th century, the industries of Electricity, Chemistry and Pharmaceuticals had the partnership of universities and, throughout the

20th century, scientific research gave support to war industry. Today a more intense collaboration is demanded since to be competitive the production process becomes less empirical and more dependent on scientific research.

The university involvement in the process of economic and social development has been often criticized for the alleged conflict between its traditional and the new roles. The assumption, however, is that the university autonomy in defining its central functions would be preserved and by no means affected by the new attributions. It is important to highlight the "double-handed" sense of the university-business relationship: not only science feeds and contributes to the development of technology, but the latter often precedes scientific knowledge, by using the method of trial and error and by accumulating empirical knowledge related to a phenomenon what tends to stimulate efforts for its scientific explanation. (Rosenberg, 1982).

Since the 1990s, Brazilian governments have been implementing policies to promote the transfer of scientific knowledge aiming at promoting the development of innovative capacity and the internationalization of companies. The Brazilian Innovation Law (inspired by the United States Bayh – Dole Act), formulated in the 1990s and approved in 2004, created legal mechanisms that favor the interaction between universities and public research institutes by regulating the establishment of external partnerships and making mandatory the creation of Technology Transfer Offices to manage the university innovation policy. Other laws, programs and mechanisms were instituted, as tax incentives for companies that develop technological research with the hiring of masters and doctors, employed in technological innovation activities internally companies.

The research

The paper presents preliminary results of a research in process aiming at giving a general overview of the current university-companies relationship, in selected regions in Brazil. The data were gathered through the National Council of Scientific Research (CNPq) from the 2016 Directory database, which includes all registered academic research groups in activity, in the country. The research groups with external relationships should respond to a questionnaire informing about their relationships. Our research considered eight Brazilian universities located in the south and southeast of the country (the region represents about 63 percent of the GDP); the universities selected shelter technological parks and incubators acknowledged as having satisfactory performance and together they have more than two thirds of scientific research groups in the country.

Charter 1 — Brazil: Concentration of CNPq Research Groups (2016)

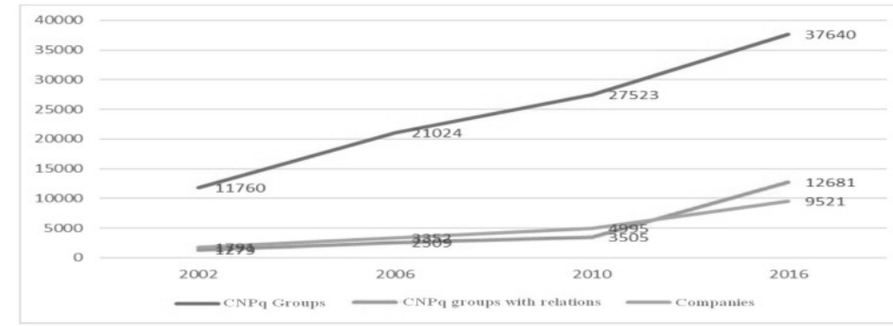
Source: CNPq Research Group Directory, 2017

The findings

Preliminary data analysis indicate some interesting findings.

The total number of registered research groups has increased significantly, in the period 2002–2016, as well the total number of researchers with doctoral degree (from 27 662, in 2000 to 130 140, in 2016) and the number of research institutions (from 224, in 2000 to 531, in 2016).

Charter 2 – Number of CNPq Research Groups: a) total; b) with relationships c) companies (2002–2016)



Source: CNPq Research Groups Directory, 2016.

The number of interactions between groups and companies differs according to the knowledge fields:

Table 1

Sampled research groups performance by fields, 2016

Fields	No. Groups	Groups + Cos	%
Health Sciences	1.538	45	3
Hard Sciences	1.104	98	8
Biological Sciences	1.027	72	7
Engineering	931	197	17
Agricultural Sciences	390	65	14
TOTAL	4.990	477	

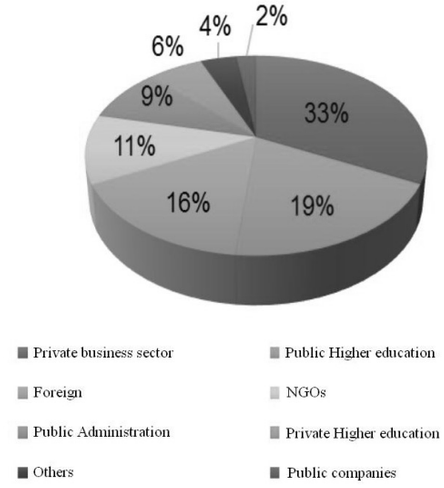
Source: Elaboration by the author from sample 2016 CNPq Database

Engineering, Agrarian Sciences, Hard and Earth Sciences (Chemistry, Computer, Geology, Mathematics, Physics Statistics) are the fields more interactive with companies. Engineering has the higher interactive performance with companies. The same is true in different countries and this is a result of the applied character of that field that makes it easier for researchers to interact with the economic sector differently, for instance, from textiles and machinery, traditionally based on practical solutions. In Engineering, Electronics and Chemical industries are more R&D intensive and more used to interact with research institutions and universities. In Brazil, Engineering sub areas as Mining, Metallurgy, Oil and Aeronautics have a reasonable stock of knowledge both, in the university and in the companies.

Agrarian Sciences is a case of success in Brazil: it has transformed the country in one of the world's major producers of grains and proteins. The development of scientific research in this field has its origin in the 19th century applied to the coffee culture, and in the 20th century with other cultures, especially, soybean, what resulted in a significant economic impact. This example supports the thesis that the development of innovations requires the existence both, scientific capabilities that can be transferred to agents with the capacity to innovate.

Considering the totality of CNPq research groups that maintained relationships with external organizations, in 2016, 35 percent were companies (33 percent were private and 2 percent were public/state); the rest 65 percent were other kind of institutions supposedly not involved directly with technological innovation: public higher education (19 percent) and private higher education institutions (6 percent); non governmental/nonprofit organizations (11percent); government organizations (9 percent) and activities related to goods pertaining to companies located abroad (16 percent; ex., airplanes). The relationships with companies (private and public) is little more than 1/3 of all external relationships. The data suggest that despite the significant increase in the numbers of research groups maintaining external interactions, the impact on the economic sector innovative performance would be not significant.

Charter 3 – Organizations in relationship with CNPq Research Groups (Brazil, 2016)



Source: CNPq Research Groups Directory, 2017.

One way to assess the possible gains for the company and for the university from their relationship is to know the nature of the relationship and the remuneration involved — two questions that are in the CNPq Directory survey. The most frequent responses in our sample regarding the nature of the relationship were: "*scientific research **with** immediate results*"; "*scientific research **without** immediate results*" and "*transfer of technology developed by the group to the partner*". Concerning remuneration: "*Transfer of monetary resources from the partner to the group*"; "*partnership without transfer of resources of any kind, involving exclusively risk relationships*"; "*Other forms of remuneration that do not fit into any of the above*".

Table 2

Sampled research groups with external relationships: types and remuneration, 2016 (%)

		%
Types	Scientific research **with** immediate use of results	33
	Scientific research **without** immediate use of results	23
	Transfer of technology developed by research group to the partner	9
Remuneration	Transfer of resources from the partner to the research group	33
	Material transfer to research group activities	17
	Other forms of remuneration	13

Source: author elaboration from Sampled Research Groups CNPq, 2016.

CNPq survey does not specifies the precise meaning of the answer choices; they can be freely interpreted by the respondents. It is supposed however that the first mentioned kind of interaction involves a joint research in which the company seeks for immediate solution for a specific technical problem. This kind of interaction supposedly has a short duration and therefore a minor impact on the catching up process, although a transfer of specific knowledge to the company may occur. Concerning the "*scientific research **without** immediate results*", supposedly the partners would be involved on the development of a research project aiming at future developments. This kind of interaction requires a longer duration and the likelihood of having a technological and innovative impact is higher. (SUZIGAN, W. et al. 2011, p.50). The third most frequent kind of relationship was "*transfer of technology from the group to the partner*", that supposes the acquisition of a product or a technological package created by the group (as software or a patent license); it may involve exchange of knowledge, but a minor innovative impact. (SUZIGAN et al.2011).

Below, there are illustrations of different kinds of relationship and remuneration between researchers and the companies found in our sample:

1. Scientific research **with** immediate results.

a) "*The companies gave us data and information about industrial processes. At the end technical reports were delivered to them. There was no payment by the companies.*" (Field: Agrarian Sciences)

b) "*We tested their equipment and delivered a technical report. No payment was involved.*" (Field: Agrarian Sciences)

2. Scientific research **without** immediate results

"*The objective was to identify possible future applications from research findings by master and doctoral students related to a research project which involves international patents (WO2008098324 and NR BR2007PI00517). The company provided scholarships to train hu-*

man resources in the field of plasma in new materials and processes with several applications in technological innovation also related to the patent mentioned above." (Field: Chemistry)

3. Transfer of technology from the group to the partner

"The companies gave us data that we analyzed; the findings were published in articles; the companies can use whatever they find more appropriate, as process improvement, development of new products, use of wastes." (Field: Food Chemistry and Biochemistry)

The presupposition is that a successful partnerships between university and companies would require the partners' commitment to an active and extending joint research activity; sporadic collaborations without a real interaction are unlikely to generate satisfactory results for improving companies' innovative capacity.

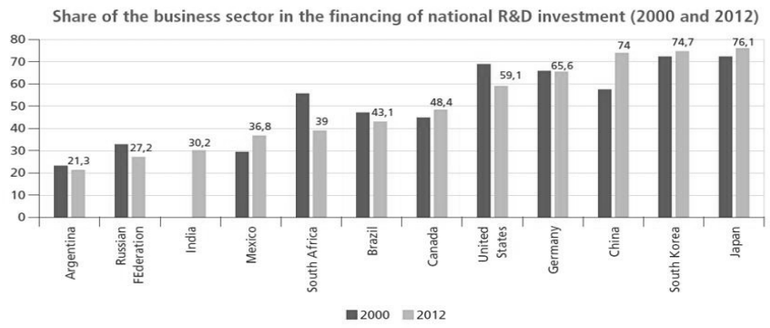
Among the descriptions above the "relationship without immediate results" would best fulfill the requirements to achieve higher levels for the development of innovations. The existence of international patents by the group and the investment in training people by the company indicates the combination of a higher scientific level and the objective of transforming scientific knowledge in innovation.

The other two descriptions suggest weak relationships: one of them could even be considered as non existent as a mutual involvement.

The findings showing the weak relationship between researchers and companies is supported by data from the Global Innovation Index, 2017, on university and companies research collaboration, where Brazil is ranked 84th, among 127 economies. (CORNELL University, 2017).

Concerning forms of remuneration, the most frequent among the sampled research groups are: a) transfer of monetary resources from the companies to the groups and b) transfer of research inputs from the companies to the groups. In both cases, the partnership resulted in private contribution for research financing. Generally speaking, the R&D private investments, in Brazil, are lower than countries at the technological frontier, where the private sector is responsible for most of R&D investments: in 2014, the private sector, in Brazil, invested 45% of total expenditures in R&D, while South Korea invested 76%, Japan, 75%; China, 75%; United States,70%; Germany, 66%. (Brazil, Science, Technology, Innovation and Communication Ministry. Accessible in: http://www.mctic.gov.br/mctic/opencms/indicadores/comparacoesInternaconais/8.1.5.html; Access, 22.08.2017).

Charter - 4



Source: World Bank Development Indicators. Available at: <https://goo.gl/TBqd6l>. UNESCO, available at <https://goo.gl/teCySn>. MCTI (Brazil). Available at: https://goo. gl/4KQbyg : *apud* Zuniga (2016)

Our findings confirm the conclusions by the National Research on Innovation (PINTEC) whose 2014 survey showed that the majority of the innovations produced by the Brazilian innovative companies consist of "new to the firm" or "new to the national market".

Charter 5 -

Source: PINTEC/IBGE. Available at: https://goo.gl/HJUK8F: *apud* Zuniga (2016)

In the Global Innovation Index, 2017, Brazil is ranked 69th in **Innovation** among 127 economies and scored 33 in 100, performing behind peer economies such as: China which ranked 25th, Russia 43rd, South Africa 54th and India, 66th. (CORNELL University, 2017).

Technological weakness reduces the country's capacity to compete internationally. Brazil is the least internationally integrated country among BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa). (OECD, 2014).The country international isolation is an obstacle for domestic companies to profit from available global knowledge and to improve its technological capacity.

More than a decade of the implementation of the Innovation Law and several other public policies, the impact on companies innovativeness is still very poor. One may conclude that laws and public incentives cannot, by themselves, overcome unfavorable features that are embedded in a society; laws can be effective when supported by society's strategic pillars. It comes to mind Douglass North (2007) notion of "path dependence" in the sense that it is not enough to adopt or copy external organizational and institutional formulas, since the present choices are somehow the result of past choices that interfere with the configuration of the present.

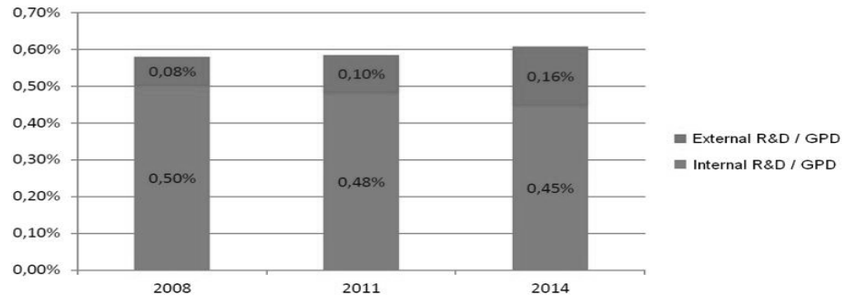
In Brazil, a paradox looms out: public support policies towards innovation are challenged by unfavorable institutional and organizational environment, in different areas: lack of a consolidated scientific infrastructure; lack of qualified personnel in technological fields; lack of a culture focused on innovation, both in the academic and business environments; lack of an institutional framework prepared to fulfill the demands of the new context, especially, regarding areas as financing, legal framework, taxation and administrative practice, norms and values.

Lundvall, (2017), asserts that to establish effective relationships between academic researchers and companies, it is necessary that the companies develop the capacity to elaborate and communicate their demands to researchers in scientific terms, so that the collaboration between both parties can result in mutual profits. Companies with internal R&D capability are supposed to be more successful in university cooperation than the ones that

do not have that capability. The R&D capability would also mean competence to seek and to assimilate external knowledge aiming at its use in the business. The little the cultural gap between the university and the companies, the more they may collaborate fruitfully.

Brazilian public policies were aware of that and have introduced programs to encourage companies to recruit labor holding master and doctoral degrees to perform P&D activities within the companies. However, to hire a graduate professional alone is not sufficient; for successful outcomes, it is necessary an adequate research environment. As shown below, the number of companies developing R&D activities, in Brazil, is very small and external R&D activities are increasing.

Charter 6 – Internal and external investments in R&D in relation to GDP (all the innovative companies)



Source: De Negri et al. (2016), p.6

To sum up, a closer relationship between the university and companies is very important for the catching up process in developing countries, since the companies lack up to date technological information and capacity to incorporate scientific knowledge in their productive processes. However, despite extensive supporting legislation, in Brazil, many obstacles persist. On the side of universities, a reorganization is necessary. For instance, researchers' collaborative activities with the companies are not acknowledged as criteria for employment and/or career advancement. Those restrictions represent a discouragement for researchers to develop joint research activities with business. The isolation of the Brazilian university is evident when we see that 68 percent of researchers, in 2010, were working full-time in higher education institutions, in contrast to China and Japan where only 20 and 19 percent, respectively, were working full time in higher education institutions. Indeed, the kind of training developed by the Brazilian higher education tends to prepare students to become mainly academics and not professionals working in the companies.

However, regarding that issue it is not clear which is cause and which is consequence. It is possible that the professionals go to the academic work due to the companies low technological level or it may be that the low technological level is a result of the university isolation.

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