XVIII ENCONTRO NACIONAL DE ECONOMIA POLÍTICA
Belo Horizonte, 28 a 31 de maio de 2013.

Sessão Ordinária

Área de Submissão: economia industrial, serviços, tecnologia e inovações.

Innovation System and development in Latin America: University-Industry interactions in Brazil.[1]

Márcia Siqueira Rapini

BSc in Economics from Federal University of Minas Gerais (UFMG), M.Sc and Phd in Economics of Industry and Technology both from Federal University of Rio de Janeiro (UFRJ).
Professor at Federal University of Minas Gerais (UFMG).

msrapini@cedeplar.ufmg.br

Tulio Chiarini

BSc in Economics from Federal University of Minas Gerais (UFMG), M.Sc in Economics from Federal University of Rio Grande do Sul (UFRGS), M.Sc in Innovation Management from Scuola Sant'Anna (Italy),
Phd student of Economics at University of Campinas (UNICAMP).
Science and Technology Analyst at National Institute of Technology (INT).

tulio.chiarini@int.gov.br

Pablo Felipe Bittencourt

BSc in Economics from Federal University of Santa Catariana (UFSC), M.Sc in Economics from Federal University of Santa Catarina (UFSC) and Phd in Economics from Fluminese Federal University (UFF).
Professor at Federal University of Santa Catarina (UFSC).

pablofelipe.bittencourt@gmail.com

ACKNOWLEDGEMENT

The authors would like to thank Dr. Laura M. Pereira from Harvard University for her suggestions in reviewing this manuscript. Opinions expressed herein are those of the authors only. They do not necessarily reflect the views of, or involve any responsibility for, the institutions to which they are affiliated. Any errors are the fault of the authors.

[1] This paper is based on a prior paper: Rapini *et al*. (2012).

Innovation System and development in Latin America: University-Industry interactions in Brazil.

ABSTRACT

The objective of this paper is to deepen the understanding of diffusion and use of knowledge in a broad perspective of a National Innovation System. It takes into account the stylistic features of the Innovation System in Latin America, specifically in Brazil, focusing on its university-industry relations. We present data from a survey conducted with firms and universities in Brazil during 2009, the "BR Survey". We find that contrary to stylized facts, Brazilian universities do more than consulting activities and routine services. They are also engaged in short and long-term R&D projects. We also find that interactions with firms reinforce universities' mission of human resources training and generates new knowledge for universities. Brazilian firms themselves are also changing. They are increasingly involved in innovative activities and also in more sophisticated interactions with universities. They are engaged in interactions with universities and research institutes; looking for codified and tacit knowledge, for testing and routine services and also for human resources.

Key-words: University-industry relations, Innovation System, Brazil.
JEL code: O33, I23, I28

In Latin America, it is a relatively
easy task to create organizations
to foster innovation, but it is quite difficult
to make them operate as bridges between people.

Arocena and Sutz (2000).

INTRODUCTION

It is well known that universities and public research institutes are key organizations for fostering socioeconomic development once they are engaged in creating and disseminating knowledge. However, the linear model where innovation is seen as emanating automatically from science is misleading and universities' role in the innovation system should not be exaggerated (LUNDVALL, 2007). Their main role remains the production of knowledge, the training of graduates for the labor market and contributing to capacity building.

Codified knowledge can move from universities to industry relatively quickly, nonetheless tacit knowledge, network relationships and other accumulated experiences also contribute to learning and capacity building, but are more difficult to be transferred. Thus, important elements that affect interactive learning are informal and difficult to measure.

In a broad perspective Lundvall *et al.* (2009) show that social institutions, macroeconomic regulation, financial systems, education and communication infrastructures and market conditions have an impact on the learning and capacity-building process, which in turn have an impact on socioeconomic development. The perspective focuses on interactive learning through structures and

relationships, however, it is not easy to define which institutions, organizations and structures should be included in the analysis.

The system of interacting private and public firms, universities, and government agencies aiming at the production of science and technology is called the innovation system[2] and this interaction among organizations may be technical, commercial, legal, social, and financial. The goal of the interaction is the development, protection, financing or regulation of new science and technology. (NIOSI *et al.*, 1993).

Thus, mechanisms that allow greater innovation and capacity-building both through interactive learning among organizations and science are *sine qua non* for economic development. That is the reason why studying university-industry relations is relevant and attention should be given not only to the functioning of universities and research institutes, patents and publications or technology but also to elements such as willingness of firms to cooperate with scientific institutions and other intangible elements. (LUNDVALL *et al*., 2009).

The objective of this paper is to deepen the understanding of generation, diffusion and use of knowledge in a broad perspective of a National Innovation System, taking into account the Innovation System stylistic features in Latin America (such as Dagnino (2007) and Arocena and Sutz (2003)), focusing on university-industry (U-I) relations in Brazil. For that we present data from a survey realized with firms and universities in Brazil during 2009, the "BR Survey".

This article will be organized as follows: the first section shall present briefly the university-industry relation from the Latin American perspective. In order to realize this goal, we will make use of the current available literature that discusses this question. The second section presents the importance of U-I in an innovation system. The third section presents some facts regarding Brazil: innovation and industrial policy and university-firms interaction. The third section presents the "BR Survey" data: how the survey was designed and university and firms' survey results. Section four shows the results from the "BR Survey" from both university and firms' perspective. From the university survey we analyze the mode of interactions, the results, the benefits and the channels for information exchange. From firms' survey we analyze the modes of interaction, results and resources produced by university and research institutes that are important to firm's innovation and their incentives for collaboration

From the investigation of relationships in section five we will be able to analyze the role of universities in knowledge generation and in firms' innovation. We will also be able to provide

[2] According to Lundvall *et al.* (2009) "The national innovation system is an open, evolving and complex system that encompasses relationships within and between organizations, institutions and socio-economic structures which determine the rate and direction of innovation and capacity-building emanating from processes of science-based and experience-based learning". (LUNDVALL *et al.*, 2009, p. 6).

stylistic information regarding universities' role in a peripheral context of contemporary capitalism[3].

1 U-I LINKS: LOOKING AT LATIN AMERICA

In light of the experience of developed countries, it is known that U-I integration is capable of enhancing the production of new knowledge and innovations in strategic areas to advance toward the scientific-technological frontier, increasing the capacity to absorb new knowledge, enabling technological autonomy, including the creation of know-how and increased competitiveness in strategic and dynamic sectors.

U-I integration needs highly qualified human resources and companies committed to the development process of innovation. In South Korea the State has applied many resources in higher education: in 2007, values spent (in the public domain) reached 1.9% of GDP[4], while in Mexico and Argentina in the same year, an amount equal to 0.9% of GDP was spent on tertiary education in both countries. In Brazil the amount reached 0.8% of GDP.

> *Expenditure on educational institutions is an investment that can help foster economic growth, enhance productivity, contribute to personal and social development, and reduce social inequality. Relative to GDP, expenditure on educational institutions shows the priority a country gives to education in terms of its available resources. The proportion of a country's total financial resources devoted to education results from choices made by government, enterprises, and individual students and their families, and is partially driven by enrolments in education* (OECD, 2010, p. 210).

In this sense, our view is consistent with that established by Suzigan *et al.* (2011, p. 09) which states that "universities and research institutes produce scientific knowledge that is absorbed by the companies and they accumulate technological knowledge, providing questions for scientific development."

Universities train qualified people, increase society's ability to absorb new knowledge, raise the midst of understanding of technology and knowledge from outside the company and increase the ability to use such knowledge, contributing to local technological accumulation. Moreover, universities are responsible for research of direct application in the manufacturing sector, generating competitive gains for companies that manage to transform scientific knowledge into technological innovations in industries. Thus, nothing guarantees that the production of new scientific knowledge

[3] This article is not intended to treat the history of capitalism, not even the characteristics of the contemporary capitalism. To understand the peripheral insertion of Latin America in the expansion of capitalism (1820 to 1913) look at Cardoso de Mello (1982), Furtado (1978), Sunkel e Paz (1973); to understand the modern capitalism (1913-1973) in the peripheral context of Latin America look at Fajnzylber (1983, 1989); and finally to understand the contemporary capitalism in Latin America (1973-up to now) look at CEPAL (2006), UNCTAD (2003), Fiori (2008) and Cano (2009).

[4] If we consider the private spending on higher education, the percentage of the GDP rises to 2.4%. For Argentina the percentage of the GDP rises to 1.2% and the same to Mexico, that is, 1.2% of GDP. In Chile the total (private and public) spending on tertiary education is 2.2% of GDP, for the year 2009. There are no statistics on private expenditure on higher education in Brazil. Data sourced from *Education at a Glance 2010: OECD Indicators*. Available at: <www.oecd.org/edu/eag2011>.

is absorbed and appropriated by the productive sector. The U-I link becomes relevant to the development process[5]. That said, the *ex ante* prominence given to the role of universities in the innovation process is more or less intensified according to the cultural, social, political, institutional and historical dynamics where universities are located (SUZIGAN; ALBUQUERQUE, 2011), and no guarantee, *ex post*, is expected that knowledge will gestate innovative gains for the country.

There are important differences among countries regarding their innovation systems. According to Arza (2010), the socioeconomic needs in Latin America create specific demands on public research organizations (including the universities) which are often not the same as the demands of economic activity in developed countries. Besides this, the technological dynamism of Latin American firms is not comparable to that of similar firms in developed countries. These two main features provide important constraints to effective interaction among organizations and learning capabilities in Latin America.

Albuquerque (1999), for instance, proposed the concept of non-mature innovation system, which includes Latin American countries. What Albuquerque (1999) tries to do is to call attention to important differences between innovation systems of developed countries and the ones of developing ones. Even though he is aware of the complexity of national innovation systems which may not be captured by only few data, his main analysis is based on basic statistics about Science and Technology - S&T (Research and Development - R&D expenditures, education, patents and publications). His analysis indicates a narrow instead of a broad view of the innovation system which is "problematic since elements and relationships of innovation system that have the most important impact upon the learning capacity of the whole system may be informal and difficult to measure". (LUNDVALL *et al.*, 2009, p. 10). R&D expenditures, the functioning of universities, education expenditures, patents, and publications are examples of components of the formal and narrow innovation system.

Forero (2006) suggests that local institutional problems in Latin America often lead to a low-level equilibrium trap where the interests of government, businesses and researchers do not converge in effective modernization and construction of innovation systems. According to Srinivas and Sutz (2008) historical-structural factors inherited in the context of scarcity of less developed economies leads to systemic resistance to structural and institutional changes, which is linked to various historical contingencies and policy choices. Along these lines, Srinivas and Sutz (2008) point to the weak linkage of the Science, Technology and Innovation (ST&I) system, historically asymmetric distribution of scientific, technological and institutional capabilities among regions,

[5] Studies realized in the USA and Europe highlight the contributions of universities to innovation and knowledge generation in enterprises (MEYER-KRAMER; SCHMOCH, 1998; SCHARTINGER *et al.,* 2001; COHEN *et al.,* 2002).

budget disparities for ST&I expenditure, lack of stable links between the university and industry, low rate of innovation and reduced effort in companies' R&D.

Maloney and Perry (2005) propose that the problem of innovation in Latin America is related to many factors:

> *(...) tales como las barreras a la creación de más empresas innovadoras, la deficiente capacidad de absorción de las empresas, las barreras internas (la legislación laboral, por ejemplo) o de los mercados de crédito que impiden adoptar las tecnologías existentes, así como las deficiencias de la infraestructura científica y tecnológica y la falta de incentivos a la innovación.* (MALONEY; PERRY, 2005, p. 42)[6].

So, there are many factors embedded in the way new relevant knowledge is created and transferred to different organizations and how norms and traditions shape the relations among those organizations in Latin America. Most of the problems in the innovation system in the region are structural and political, economic, historic and cultural specificities determined a specific institutional trajectory[7] that affect the Latin American ability to innovate and compete in global markets. According to Dutrénit and Arza (2010), the institution-building process in Latin America has been eclectic as a result of many swings in policy regimes throughout the decades:

> In particular, institutions that had emerged in response to import substitution policies from the 1940s to the1960s co-existed with more modern institutions devised in agreement with the liberalisation policies of the period from the 1970s to the 1990s. This mix sometimes implies a lack of consistency in policy guidelines. (DUTRÉNIT; ARZA, 2010, p. 541).

Indeed, Dutrénit and Arza (2010) are right. Policy choices in different periods in Latin American countries were many times contradictory and the constant change in the orientation of those policies created a sort of inefficient institutions, as will be demonstrated in section 3 when analyzing the case of Brazil.

For Niosi (2010) the problem in Latin America is that S&T institutions are absent or are highly inefficient, especially with regards to policies to encourage private R&D. "Latin American countries invest little in business R&D. Their policies are often inconsistent, which reveals the modest management capabilities of their public bureaucracies" (NIOSI, 2010, p. 265). Moreover, there is a lack of demand for human capital, which promotes conditions for brain drain conditions.

For Arocena and Sutz (2000) micro-innovative strengths[8] in Latin America are isolated and encapsulated. In fact, according to the authors, ST&I have never occupied a high position on the

[6] "(…) such as barriers to the creation of more innovative companies, poor absorption capacity of firms, internal barriers (for example, labor law) or credit markets, which prevent the adoption of existing technologies and the deficiencies in scientific and technological infrastructure and the lack of incentives for innovation." (Our translation).

[7] It is possible for some points between the Latin American Structuralist School and the Innovation System perspectives to converge. Both approaches recognize that the countries trace their own development trajectory according to their specificities and possibilities and that the evolution of each national economic system is affected by the country's hierarchical and power position under the capitalist system. (CASSIOLATO; LASTRES, 2008).

[8] The micro-innovative strengths in the context of evolutionary economics are related to many factors. In a micro level, firms are 'searching' incessantly for innovation (under uncertainty conditions), in order to maintain/amplify their market share. However, there

political agenda in the region. They have found empirical evidence that in Latin America the firms' external environment has relatively little importance regarding their innovative performance and within this external environment, the less important organizations are universities and research institutes.

Arocena and Sutz (2003) points out that Latin American universities had more of a consulting profile with firms than a researching collaboration. According to Aldana (2006) Latin America universities are not fully integrated to the commercialization of knowledge activities. So, the third mission[9] of Latin American universities are incomplete.

The most significant contribution of universities is human resources training. Interactions, when present, are limited to consulting activities, routine services (measuring, testing and quality control) and not high-level research and experimental development. This scenario refers to an isolated role of universities in the process of knowledge creation. Arocena and Sutz (2003) propose that Latin American universities were 'isolated university consultants' in contrast to 'entrepreneurial universities' connected in the center, articulated with more firms and involved in the production of frontier knowledge of potential applicability to the productive sector.

According to Dagnino (2007) firms located in Latin America are not interested in having a more active role in the development of scientific and technological research and do not consider it important to conduct R&D, but they are only interested in the acquisition of machinery and equipment as innovative strategy. Firms do not consider the relationship with universities and research institutes important for its innovation strategy, nor do they absorb graduates in hard sciences as occurs in developed countries. (DAGNINO, 2007). It is evident, therefore, that there are obstacles between U-I and thus the need for a new institutional arrangement.

Inside universities, there are also little interactions between basic and applied research, a small amount of multidisciplinary research and low level of cooperation between academic institutions (LUNA, 2001). Sutz (2000) explains that the evil of the pairing interaction as a result of U-I designation mechanisms is inadequate or insufficient use of existing mechanisms.

Analyzing Argentina, Brazil, Costa Rica and Mexico, Dutrénit and Arza (2010) prove that bi-directional[10] and services[11] channels drive intellectual benefits for researchers. Firms tend to

---

is no guarantee that the 'search' will be successful once the innovation will be submitted to the 'selection process', which demonstrates that firm's trajectory may not be defined *a priori*. (NELSON; WINTER, 1982). The dynamic interaction between the 'searching' and 'selection' process attests, redirects or rejects certain firm's strategies at the micro level, as well as their technological trajectories (POSSAS, 1989). Firms define competition strategies to improve their performance and their chances of survival; their decision making (under uncertainty condition) is given through routine rules, based on their history and based on the environmental conditions. In many countries, where the degree of uncertainty is high and where policies taken by government affect directly micro-innovative strength of the firms, so the micro-innovative strengths are isolated and are encapsulated, that is innovation efforts are condensed and restricted to a few sectors in the economy. According to Arocena and Sutz (2000), this creates important difficulties for a further process of articulation between actors in a National Innovation System.

[9] The first mission is 'teaching', the second mission is 'research' and the universities' third mission is the 'commercialization of new relevant knowledge' facilitating their engagement with society and industry.

[10] Bi-directional channel includes joint R&D projects, participation in networks, contract research, scientific-technological parks etc. (DUTRÉNIT; ARZA, 2010).

value the traditional[12] channel more than any other channel. However, it is the bi-directional channel that drives the best benefits, especially those related to contributions to innovation activities.

In Argentina, the most important channels of U-I interactions are the traditional and services channels. The former predominates for firms while the latter, especially consultancy, predominates for the universities. Now, regarding the benefits, intellectual benefits are the most important for the universities and production benefits are the most important for firms. The service channel provides economic benefits for researchers while commercial[13] channel does not produce intellectual benefits. (ARZA; VAZQUEZ, 2010).

Dutrénit *et al.* (2010) suggest that Mexican researchers obtain intellectual benefits from the bi-directional and the traditional channels, whilst Mexican firms obtain benefits related to production activities and innovation strategies from the bi-directional and the services channels, while the traditional channel only provides production-related benefits.

A recent paper from Fernandes *et al.* (2010) analyzed the Brazilian case and they found that bi-directional channels are relevant. As for interactions between firms and research institutes, bi-directional channels are the most important in terms of intellectual benefits for the researchers and innovative benefits for the firms.

Added to this are the research findings of Bernardes and Albuquerque (2003). For them its necessary a minimum threshold of scientific production that ensures the existence of 'critical mass' that enables the scientific infrastructure to assume important roles during the development process, as the absorption capacity. This scientific 'critical mass', therefore, apart from making technology production more efficient, is essential for the existence of adequate interactions between the system components.

We can partially conclude that the Latin American economies have similar barrier that affect U-I relations to those described for developed countries. However, they can also produce other difficulties, due to structural problems of their economy. Also present are communication difficulties, bureaucracy, inadequate research staff, lack of adequate funding, socio-cultural factors and differences in culture of the university and company in terms of R&D related to the short versus long-term. In relation to cultural differences from universities and firms has been a distinct trend of institutionalization of scientific activity in developing countries.

---

[11] Service channel includes consultancy, use of equipment for quality control, tests, training etc. (DUTRÉNIT; ARZA, 2010).
[12] Traditional channels are hiring recent graduates, conferences, publications. Personal interaction is not required. (DUTRÉNIT; ARZA, 2010).
[13] Commercial channel includes patents, technology licenses, spin-off companies, incubators etc. (DUTRÉNIT; ARZA, 2010).

2 SOME FACTS REGARDING BRAZIL

Not only did the 90's bring the 'newness' of the opening of the Brazilian economy, but it also brought the idea that "the best industrial policy is not to have industrial policy" (CANO; SILVA, 2010, p. 04) as some actions were practiced (tariff reductions for non-preferential imports, currency devaluation, reduction of credit and lack of rigor to combat unfair foreign trade practices) that led to a process of substitution of domestic production by imports even in sectors where the country had had some competitiveness (*ibid.*), greatly damaging the industry nationally[14].

Thus, the 90's marks a change in the orientation of Brazilian economic policy and began a long process of deregulation and economic liberalization. Following the international trends to neo-liberalism Brazil changed its legal institutions[15] to make the country more attractive to foreign direct investment, leaving aside its industrial and ST&I policy as a way to foster endogenous development of a strong national industry. According to Peres (2006), the opposition against the industrial policy emphasized

> (...) *un discurso que culpaba a las políticas industriales sectoriales de distorsionar la asignación de recursos y causar los desequilibrios fiscales que estaban detrás de los procesos inflacionarios. Esta posición de crítica a la política fue compartida por un número creciente de gobiernos en la región [América Latina]. Sin embargo, esa visión extrema no siempre se condijo con los hechos; incluso gobiernos fuertemente reformadores, como los de Menem en Argentina, Collor de Melo en Brasil y Salinas de Gortari en México, mantuvieron ciertas políticas sectoriales, en particular para la industria automotriz.* (PERES, 2006, p. 73)[16].

Along with the macroeconomic model used (appreciation of national currency and high interest rates) there was an increase of the external vulnerability of the country that led to inhibition of productive investments and the resumption of economic growth (*ibid.*). Industrial policies adopted in Brazil in that period had been based on the idea of 'market failures', characterized as supply policies (KOELLER; GORDON, 2009). This form of understanding led to an incorrect diagnosis of Brazilian reality resulting in a lack of planning, budgeting and coordination between policies. Moreover it resulted in inefficient and insufficient programs and actions that benefited a small number of companies that certainly would have invested in innovation activities without government support.

[14] However, some exceptions can be identified in this decade: a) installation of industry chambers, b) creation of Mercosur which granted preferential treatment to trade liberalization at the regional level; c) some industries were subjected to special protection schemes, such as automotive d) creation of Sector Funds for Scientific and Technological Development (CANO; SILVA, 2010).

[15] For more details about the legal institutional change in the Brazilian economy in the 90's look at NEVES (2002).

[16] "(...) A speech that blamed sectoral industrial policies to distort the allocation of resources and cause fiscal imbalances were behind the inflationary processes. This position of political critique was shared by a growing number of governments in the region [Latin America]. However, this extreme view is not always coherent with facts and even strongly reformer governments, such as Menem in Argentina, Collor de Melo in Brazil and Salinas de Gortari in Mexico, had some sectoral policies, particularly for the automotive industry." (Our translation)

The economic liberalization that Brazil has witnessed since the 90's and the real valorization of the exchange rate contributed to a structural transformation of Brazilian industry which had a direct impact on the creation of technology. That transformation has favored the modification of the industrial park, but has also discouraged exports and the domestic production of technology, due to the combined effect of a higher real interest rate and exchange rate appreciation. (FEIJÓ; LAMONICA, 2012).

> *La apertura económica registrada desde los años noventa y la valorización cambiaria contribuyeron a una transformación estructural de la industria. Esa transformación favoreció la modificación del parque industrial, pero también desincentivó las exportaciones y la creación y producción nacional de tecnología, debido al efecto combinado de una tasa de interés real elevada y la valorización del tipo de cambio.* (FEIJÓ; LAMONICA, 2012, p. 134)[17].

Since the 2000's, industrial policies have had a slow comeback in Latin America even with their open economies and with orthodox macroeconomic policies (PERES, 2006). In Brazil, for instance, during the 2000's, the Lula government has restored an industrial policy with the formulation of the Industrial, Technological and Foreign Trade Policy (*Política Industrial, Tecnológica e de Comércio Exterior* - PITCE), anchored by two macro programs ('Strong Industry' and 'Innovate Brazil', *Indústria Forte* and *Inova Brasil*), seeking greater involvement in international trade, however, there was a continuation of the macroeconomic policy of the previous government.

Without doubt, the PITCE permitted progress in institutional Industrial Development Policy, reintroducing it into the public policy agenda as a tool for economic development (*ibid*.). After this, other government actions were relevant to promote innovation in the industrial policy, the 'Law of Innovation' (*Lei da Inovação*), 'Goods Law' (*Lei do Bem*), 'Computer Law' (*Lei da Informática*), 'Law on Biosafety' (*Lei de Biossegurança*) and has allowed the deployment of a second stage of PITCE, known as Productive Development Policy (*Política de Desenvolvimento Produtivo* - PDP). Although they represent a step forward, both PITCE and PDP did not incorporate integration with other policies closely linked to them, for example educational policy and macroeconomic stability.

The 'Brasil Maior' Plan launched in 2011 by the Government Dilma Rousseff, continued Lula government's economic planning (PITCE and PDP) in order to sustain economic growth in Brazil, with a focus on innovation and Brazilian industrial expansion through measures such as exemptions for productive investment and exports, credit expansion and improvement of regulatory innovation. According to Almeida (2011) the 'Brasil Maior' Plan demonstrates that the government gave the industry an important role in promoting the development of the country and its strengths

[17] "Economic openness recorded since the 90's and overvaluation of the exchange rate contributed to a structural transformation of the industry. That transformation favored the modification of the industrial park, but also discouraged exports and domestic production creation and technology, due to the combined effect of a higher interest real and exchange rate appreciation." (Our translation).

are linked to pioneering some actions such as reducing taxes on investment and exports, and the significant contribution of FINEP (*Financiadora de Estudos e Projetos* – Financier of Studies and Projects) and BNDES (*Banco Nacional de Desenvolvimento Econômico e Social* – Brazilian Development Bank) financing for investment and innovation. However, Almeida (2011, p. 12) points out that even with the measures proposed by 'Brasil Maior' Plan, "Brazil is still far from being a country facilitator and promoter of investment, innovation and exportation" and with these measures it still is unlikely that the country will become more autonomous in terms of technology.

Although there are macroeconomic limitations, industrial and innovation policies are not synchronized with the educational policies. There is also a lack of coordination between public and private agents. Indeed, Silva (2012) suggests that even though there is an increase in government funding for the Brazilian universities, there is no adherence of the research conducted by universities and public research institutes to what has been declared as priority by successive governments as part of the S&T policies and other public policies oriented to social and economic spheres. Chiarini and Vieira (2011) find the same conclusion.

However, investments in R&D and in Science and Technology (S&T) had made significant progress in Brazil: from 0.71% of GDP in 1996 to 0.99% in 2006. In 2009 the R&D spending as a proportion of GDP reached 1.19%, its highest historical level, being, however, still much lower than many countries like Japan (3.44%), South Korea (3.36%), Germany (2.82%) and USA (2.79%)[18]. Those figures indicate a narrow perspective of an innovation system. According to Lundvall *et al.* (2009, p. 2) the narrow perspective aims at "mapping indicators of national specialization and performance with respect to innovation, research and development efforts, and science and technology organizations". Normally, this perspective indicates a linear approach to innovation and does not take into account the role of informal institutions influencing innovation nor informal networks (such as cultural and historical values).

Innovation, on the contrary, is an interactive, non-linear process, that is, it does not automatically result from efforts of R&D or automatically emanates from sciences. Innovation is a confluence of social, political, institutional and cultural and different developmental trajectories shape innovation systems (CASSIOLATO; LASTRES, 2008).

Evidence from the Brazilian Innovation Survey (*Pesquisa de Inovação Tecnológica* - PINTEC) shows that innovative industrial firms are growing, reaching 38.6% (or 41,262) of total firms (106,862) in 2008. This percentage was 31.5% in the first survey in 2000. Innovative firms are also increasing the resources allocated to inside R&D (28.1% of total resources to innovative activities in 2008 versus 16.7% in 2000), and are more involved in cooperation with universities

[18] Data sourced from *United Nations Educational, Scientific, and Cultural Organization Institute for Statistics* and from Brazilian Minister of S&T.

(13.4% in 2008 versus 11.4% in 2000). Silva (2012), using PINTEC database, between 2000 and 2008, affirms that 50% of firms expenditure on research activities were applied in the acquisition of machinery and equipment, that is, the firms that declared themselves innovators, only 23.5% of their expenditure were applied in activities that needed any universities' support. Silva (2012) also concludes that from the 100% of the (public and private) expenditure on S&T in Brazil for those activities that required the participation of the university, 70% came from public sector and 30% from the private sector.

Technological autonomy is not achieved without sustained efforts and increased resources (financial and human) in scientific research technology, particularly for companies (FURTADO, 1992). Strategies should be intentionally designed and results from educational policies harmonized with industrial and innovation policies. The dynamic and strategic sectors chosen, should be consistent with the technological frontier (which was well structured in PITCE with defined 'strategic options', i.e., semiconductor, software, capital goods and drugs, and 'cutting-edge technologies' i.e., biotechnology, nanotechnology, biomass/renewable energy), to significant structural modifications. However, what one finds is that the government defines important areas for development, but does not align them with the research conducted in the federal universities, these being the main source of new knowledge generation in Brazil.

2.1 U-I interactions in Brazil

In Brazil, one finds that Brazilian universities are small in scale, concentrated in humanities and applied social science, they have weak links to production activities, and applied research is circumscribed to some fields such as agronomy, mining/metallurgy, and health sciences[19]. Engineering fields germinated very late in Brazil, and graduate courses linking teaching and research activities were ushered in only in the 1960's, nurtured by federal government (SUZIGAN; ALBUQUERQUE, 2009).

[19] It can be seen that the largest share of research groups registered in the National Counsel of Technological and Scientific Development (DGP/CNPq), in 2008, belongs to the Humanities (19%), followed by Mathematics and Earth Sciences (17%) and Engineering (13%). If we examine the distribution of Brazilian researchers by area of knowledge, the greatest concentration occurs also in Humanities (19.56%). The second area with the highest concentration of researchers is Health Sciences (17.97%). By observing the publication of scientific journals, 24.69% refer to Health Sciences and Engineering represents only 9% of the total. So in Brazil there is a significant concentration of resources in the Humanities, Applied Social Sciences and Linguistics and Arts (which together account for almost 37% of the researchers), while only 13% of researchers are allocated in Engineering. This distortion may be related to the large number of Higher Education Institutions that offer various courses in Humanities areas, that require relatively low investment in infrastructure and equipment, such as Administration, Law, among others (MELLO *et al.,* 2009). A peculiarity of higher education in Brazil is that the public Higher Education Institutions are the greatest research system in the country, especially regarding the graduate programs of these institutions. In 2008, according to the Coordination for the Improvement of Higher Level (CAPES), there were in Brazil 2,718 graduate programs registered, with approximately 32% of them in Humanities areas. About 46,000 students were enrolled in graduate programs in Brazilian Higher Education Institutions in the same period: 36% of them enrolled in Humanities.

Brazil's immature innovation system (ALBUQUERQUE *et al.*, 2005) also faces a lack of synchronization between the incentive regimes of science and technology policies that on the one hand define areas that are important for playing technological and economical catch-up and on the other hand do not have a well-defined policy to allocate human resources to those areas nor does it have an aligned tertiary educational policy. In Brazil, the main locus of knowledge production is the public university which plays an important role in the process of creating and disseminating new scientific knowledge and new technologies through basic research, applied research, development and engineering. They also have the role of supplying skilled labor to meet the demand of the productive sector. Within universities, research staff are renewed and knowledge is updated.

The university-industry interaction in Brazil suffers from structural problems[20] however we cannot say there is no interaction between university and industry in the country. Contrary to conventional wisdom, we can find historical examples that have demonstrated a close relationship between some Brazilian universities (and research institutes) and industry, however, the maturation of successful cases of university-industry interactions took time and was the result of a process of a long-term institutional building with strong support and intervention of the Brazilian government.
One example of such successful university-industry relation can be the case of the Brazilian Aeronautical Company (Empresa Brasileira de Aeronáutica - Embraer) which had benefited from the proximity to the Technological Institute of Aeronautics (*Instituto Tecnológico de Aeronáutica* - ITA), another one can be the rich interaction between the National Steel Company (*Companhia Siderúrgica Nacional* - CSN), Companhia Vale do Rio Doce and the Department of Metallurgy and Material Engineering of the Federal University of Minas Gerais (UFMG), which resulted in good performance for mining and the Brazilian steel industry, but either the extraction of petroleum is an important focus of generation of relevant knowledge, evolving Petrobras and Alberto Luiz Coimbra Institute of post-graduation and research in engineering of the Federal University of Rio de Janeiro (SUZIGAN; ALBUQUERQUE, 2011).

In Brazil one can find some particularities, especially regarding the Brazilian universities' role: they act somehow differently from the stylized fact mentioned in part 1. Brazilian universities do more than consulting activities and routine services (that is technical evaluations, project management, testing and engineering services), being somewhere in between the 'consultant university' and the 'entrepreneurial university' as will be described in the following sections.

[20] We can point out that structural problems are historical inherited: weak articulation of ST&I, historically asymmetric distribution of S&T capabilities and institutions between regions (in terms of institutional infrastructure, critical mass, etc.), budget disparities on ST&I in states and regions, lack of stable links between university/research institute and firms, low rate of innovation and reduced firms' effort in R&D.

3 DATA AND METHODOLOGY: THE 'BR SURVEY'

To fulfill the objective of evaluating the characteristics of U-I relations in the Brazilian National System of Innovation, we used a database of a survey realized, in 2009, with firms, universities and research institutes located in Brazil, named "BR Survey". Different questionnaires were sent do firms and research groups affiliated to universities/research institutes in order to infer characteristics of these interactions in Brazil. The questionnaire involved some key questions about the nature of university-firms interactions as: 1) types of relationship; 2) results from the interaction; 3) benefits; 4) difficulties with the interactions; 5) channels of information; 6) source of funding, among other.

Research groups and firms were requested to answer the questions, giving consideration to interactions that had taken place over the last three years. The university questionnaires were sent to 2,151 research group's leader and we received answers from 1,005 research groups (46.7% of total), located in 26 Brazilian states. The firm`s questionnaire were sent to 1.622 firms located in Brazil that interact with universities and research institutes. In the end, 319 firms (18.9% of total) responded the questionnaire[21].

Each question presents a 4 level scale embracing not important, little important, moderately important and very important. In section 5 we analyze groups and firms' responses regarding moderately and very important. The 1,005 research groups are distributed in six large scientific areas. The areas and total number of groups are described in table 1. As shown among the groups that answered the questionnaire 32% are from engineering, 22% are from biology and health sciences, 20% are from agrarian science, 15.7% from earth sciences and 10% from humanities. Besides this, 79.8% of research groups are affiliated to public universities. Only 13.7% of groups are from private universities, and 6.5% are from public research institutes.

Table 1 - Number of Groups by Science & Engineering fields, Brazil, 2009.

Scientific areas	Groups	
	Number	%
Engineering	323	32.1
Biology and Health Science	221	21.9
Agrarian Science	200	19.9
Earth Science	158	15.7
Humanities	103	10.3
Total	1005	100

Source: Authors' own. Data sourced from BR Survey, 2009.

[21] The statistical significance test for the sample of the "research groups" (1,005 groups) indicates that the percentages of each response has a margin error of ± 3.09%, considering a 95% significance level. For the "firms group" (319 firms), the extrapolation error margin for the population was ± 5.48%, considering the same significance level.

Among firms' sample 34% are small firms, 32% are medium firms and 34% are large firms[22]. 58% of firms innovated in product or process during the considered period. The innovation product rate was 51%, while the process was 32%. Furthermore, only 6.7% of firms had only process innovation, while 26.7% had only product innovation. In other words, product innovations are more frequent and a firm that innovates in product also had a process innovation (POVOA; MONSUETO, 2011).

4 RESULTS FROM THE 'BR SURVEY'

This section is divided in two subsections. The first presents some results from the university survey, regarding what was presented in the literature review. As it will be shown Brazilian universities do more than consulting activities and are also engaged in R&D projects of short and long-term. The first part analyses four questions from university survey: a) the modes of interaction - the instrument or mechanism used for collaboration with firms; b) the (tangible) results from the interaction; c) the channels for information and knowledge exchange in interactions; and d) the benefits from interaction[23]. The second presents results from the firm survey, and we analyze three questions: a) the modes of interaction; b) results and resources produced by university and research institutes important to firm's innovation; c) reasons for collaboration with university and research institutes. Brazilian firms interact with universities to solve production problems, but they are also engaged in more sophisticated interactions as research projects.

4. 1 The University survey

Table 2 shows the modes of interactions according to their importance to the research groups. On average, the leading modes of interaction are "short-term R&D collaborative projects" (68.6%) and "consultancy" (67.6%) followed by "training and courses" (62.8%) and, with less importance, "technical evaluations/project management" (56.7%). So Brazilian universities are engaged in consulting activities, routine services (technical evaluations, project management, testing and engineering services) but also with R&D projects (from short and long term). So, research groups are engaged in interactive process and are not isolated as suggested by Arocena and Sutz (2003).

[22] Firms were classified according to employees number: micro and small firms (0 to 99 employees); medium firms (100 to 499) and large firms (more that 500).

23 The difference between results and benefits are that the former are generally related to tangible results and is easier to identify from a specific mode of interaction. The benefits can be more subjective and embraces tangible and intangible results (as "reputation" for example) and generally are the leader's impression from the historical group's interactions.

As we can see, the format of the interactive process that defines knowledge diffusion between research groups and Brazilian firms is highly heterogeneous. The highlighted relevance of interactive learning through R&D activities (either through short term or long term projects) point out to a group of actors involved in innovation processes of high potential impact, typically featuring high level qualifications, tacit knowledge diffusion and high absorptive capacity of firms. In processes such as those, other learning modes can also be relevant, by boosting tacit knowledge transfer, between them, among them, temporary personnel exchanges, which has been selected as highly relevant for almost half of the interacting research groups in Brazil.

On the other hand, the relevance of activities such as "training and courses" (62.8%) and "technical evaluations/project management" (56.7%) and in a lesser degree, tests (38,1%) and engineering services (29,5%) point out to research groups which serve firms with problems related with incremental process innovations but also with organizational ones. The relevance of such research groups is in line with the notion that Brazilian S&T institutions have an active role in innovation processes, typical of Latin American countries, where there are efforts of absorption and technological adaptation of products and processes generated abroad (DAGNINO, 2007). It is worth to mention that such activities improve the quality of innovation systems because they represent knowledge and innovation diffusion (EDQUIST; HOMEMM, 2008).

From the information above, it can be argued that the behavioral pattern of research institutes inserted in learning processes is heterogeneous enough to not be considered isolated as perceived by Arocena and Sutz (2003) . Besides, we understand that activities such as consultancy and tests, which are considered less relevant by Arocena and Sutz (2003) are actually important because they serve as boosting elements of knowledge and innovation diffusion. As Christopher Freeman put it: "evidence accumulated that the rate of technical change and the economic growth depended more on efficient diffusion than on being first in the world with radical innovations and as much on social innovations as in technical innovations" (FREEMAN, 1995, p.10, *apud* LUNDVALL, *et al.,* 2009, p. 09).

The heterogeneous role of research groups in the Brazilian Innovation System reveals that such institutions hold relevant competences, built throughout the years with a broader function than the one described in the linear model of innovation and even by Arocena and Sutz (2003), even if argued that the interaction frequency is low.

Table 2 - Modes of interaction between Research Groups and firms, Brazil, 2009.

Modes of interaction	Total(*)
Short -term R&D collaborative projects	68.6
Consultancy	67.6
Training and courses	62.8
Technical evaluations, project management	56.7
R&D projects that complements innovative activities in firms	54.0
Long -term R&D collaborative projects	51.3
Temporary personnel exchanges	51.1
Technology transfer	47,7
Tests	38.1
R&D projects that substitutes innovative activities in firms	37.3
Engineering services	29.5

Source: BR Survey, 2009, author's elaboration.

Table 3 presents the results of the interaction, according to the research groups. The results were also grouped in two subsets according to their nature – academics or commercial/business. The four most important results are directly related to academic activities: new research projects (84.5%), human resources and student education (82.7%), thesis and dissertations (82.0%) and publications (80.3%). So, interactions with firms reinforce universities' mission of RH training and also generate new knowledge for universities (thesis, dissertation, publications and research projects). Results related to industry are the second most important: new products and devices (58.5%), improvements of industrial processes (49.8%), improvements in industrial products (46.8%) and new industrial processes (46.3%). So, it confirms that university knowledge is important to solve problems in firms' innovative performance (KLEVORICK *et al*., 1994) and also to suggest new products and devices (COHEN *et al.*, 2002).

Table 3 - Results of interactions with firms, Brazil, 2009.

Type	Results	Total (%)
Academic	Scientific discoveries	60.2
	New research project	84.5
	Human resource and students education	82.7
	Dissertations	82.0
	Publications	80.3
Commercial / business	Patents	45.3
	Software	33.1
	Design	19.2
	Spin-offs firms	24.3
	New products and devices	58.5
	New industrial process	46.3
	Improvement of industrial products	46.8
	Improvement of industrial process	49.8

Source: BR Survey, 2009, author's elaboration.

Table 4 shows the channels of information for transferring knowledge in interactions between research groups and firms. The channels were grouped in four types according to the traditional role of universities – open science and educational channels – and to the new role of

universities as “entrepreneurial” (ETZKOWITZ, 1999) – commercial and university-firms research collaborations channels.

The principal channels of information between universities and firms are the ones related to the “open science”, as publications and reports (75.0%), public conferences and meetings (74.4%) and to the “educational channel” - training (71.0%). These are channels of information directly related to the research and teaching roles of universities and are in accordance with other surveys in literature (COHEN *et al*., 2002).

Among the “university-firms research collaboration channels” the formal channels “research contract” (74.9%) and “R&D cooperative projects” (70.6%) are complemented especially by “informal information exchange”, conforming a pattern of learn and the building capacity intensely defined by formal and informal channels. This last type of channel are more frequent when the agents are geographic closed. This may be an indicator of the presence some local innovation systems consistent/efficient, contrasting with others.

Additionally, in general, the results stressed that there are a mix of channels of information operating in Brazil, similar to ones present in developed countries.

Table 4 - Channels of information between research groups and firms, Brazil, 2009.

Type	Channels of information	Total(%)
“Open science”	Public conferences and meetings	74.4
	Publications and reports	75.0
Educational channel	Training	71.0
	Recently hired graduates	58.4
Commercial channels	Temporary personnel exchange	53.2
	Patents	43.0
	Licensed technology	38.7
University-Industry research collaboration channels	R&D cooperative projects	70.6
	Research contract	74.9
	Spin-off from universities	37.2
	Engagement in network with firms	46.1
	Incubator	39.8
	Science and/or technology parks	40.2
	Informal information exchange	66.1
	Individual consulting	52.3

Source: BR Survey, 2009, author's elaboration.

Table 5 shows the benefits of interactions with firms targeted by research groups. The benefits were grouped in three types: (1) the ones related to access to new knowledge or knowledge augmenting, referred to as ‘knowledge’; (2) the ones related to ‘research resources’, including financial resources, inputs and access to equipments; (3) and the last is associated with the ‘Science Ethos’ and includes reputation.

Table 5 - Benefits of interactions with firms, Brazil, 2009.

Type	Benefits	Total
Knowledge	Insights for new collaborative research projects	81.6
	New research projects	85.9
	Knowledge or information exchange	81.8
	Access to new networks	72.3
Research resources	Shared access to equipment/instruments	53.9
	Material input for research	70.1
	Financial resources	69.9
Science Ethos	Reputation	70.6

Source: BR Survey, 2009, author's elaboration.

Following evidence in the literature (LEE, 1996; MEYER-KRAMER; SCHMOCH, 1998) the primary benefits are the ones related to knowledge – new research project (85.9%), knowledge information and exchange (81.8%), insights for new collaborative research projects (81.6%) and access to new networks (72.3%), with less relevance. In general, the research resources seem to be less relevant, but suggest that the private sector can improve the researches with different researches. This information resides in the fact that the search for new knowledge sources seems to be the largest motivation for researchers to engage in interaction with firms. Therefore, interaction with firms is not related with deviations on researchers' functions but with processes of competence building through complementary knowledge exchange, capable of generating benefits, considered relevant in the academic world.

In accordance with the outcomes in table 3, new research projects are an important benefit, what can be explained by interactions with firms as source of new ideas and problems to be solved. Similar results were found from Siegel *et al.* (2003) analyzing technology transfer between firms and universities in USA.

In line with the interpretation of the results of table 5 we found (in table 6), that the interactive groups have more PhD researchers, scientific articles, theses and dissertations on average per group[24]. These scenarios stress the importance of critical mass and relevant research to established cooperative arrangements with firms (VAN DIERDONCK et al., 1990) and also that science-industry interactions tends to increase research groups' activities and R&D productivity (RANGA et al.,2002). In another direction, these data suggest that some interactions with firms is a bidirectional flow of knowledge that enhance research groups activities, expressed in new scientific discoveries, new research projects, publications, theses and dissertations.

[24] Groups in the humanities are the exception.

Table 6 - PhD researchers, articles, theses and dissertation on average per groups, interactive and no interactive research groups, Brazil, 2009.

Science and engineering areas	Interactive groups				Non-interactive groups			
	PhD	Articles	Thesis	Dissertation	PhD	Articles	Thesis	Dissertation
Engineering	5.9	36.2	5.2	18.0	5.9	30.6	4.2	14.3
Agrarian Sciences	8.4	105.4	11.3	24.7	7.2	87.2	8.3	18.5
Biology & Health Science	6.6	85.9	6.6	15.9	5.7	62.6	4.5	10.8
Earth Sciences	6.3	55.4	4.9	14.8	4.9	43.2	3.2	8.8
Humanities	5.0	29.5	2.5	5.2	4.10	22.5	2.1	9.98

Source: CNPq's Directory of Research Groups, Census 2008, author's elaboration.

4.2 Firm's Survey

Table 7 presents firms' responses regarding modes of interaction in university-firms interaction. The modes of interaction were grouped in types, in order to organize the analyses. The most relevant modes[25] included the traditional ones as "open science" and the formation of qualified human resources (undergraduate and postgraduate staff hired) combined with informal and formal channels of collaboration that confirm the notion that the interaction pattern between U-I in Brazil is vastly heterogeneous. As highlighted by the research groups, both research activities (especially via research conducted along with universities, but either by firm outsourcing research from universities (81)) and consultancy ones (78), performed by Universities, are important modes of interaction. This confirms the interpretation that Universities are not exclusively focused on consultancy activities, even though it is an important function of them, as understood by firms. It is important to highlight the relevancy given by firms to the participation in networks involving universities (68) indicating that there is a significant group of firms that understand that being involved with knowledge-related institutions is of importance for their core activities. This notion also diverges from the generalization made by Dagnino (2007) that states that Brazilian firms are only interested in the acquisition of machinery and equipment as innovative strategy.

Finally, we consider relevant to point out the role of informal relations, which include network participation, but also "informal information exchange". So the modes of interaction used by firms embraces formal and informal mechanisms, as also more sophisticated instruments of research. This view of firms confirms the notion that knowledge absorbed by firms in the interactive learning processes with universities involves activities of diverse nature, which include codified knowledge interpretation (publications and reports, and firm outsourcing from universities), to tacit ones learned from face to face interaction (through conferences and meetings, and joint research activities or informal information exchange).

The most frequent responses were 'research conducted with universities' (107 firms) and 'publications and reports' (104 firms). On average the more frequent modes of interaction, declared by firms, are the ones related to "open science", to educational university mission. Also are some

[25] Set in a discriminatory way as more than 20% of firms that considered moderately or very important.

modes related to 'university-firm collaboration', as consultancy (78 firms), informal information exchange (86), firm outsourcing research from universities (81) and joint research mentioned before.

Table 7 - Modes of interaction in university-firms interactions, firms' response, Brazil, 2009.

Types	Modes of interaction	Moderately or very important	
		Number	%
"Open Science"	Publications and reports	104	32.6
	Public conferences and meetings	85	26.6
Educational	Undergraduate and postgraduate staff hired	89	27.9
Commercial	Technology licensing	50	15.7
	Patents	49	15.4
	Temporary staff Exchange	41	12.9
University-firm collaboration	Consultancy with individual researchers	78	24.5
	Firm outsourcing research from universities	81	25.4
	Research conducted along with universities	107	33.5
	Participation in networks involving universities	68	21.3
	Incubators	30	9.4
	Science and/or technology parks	41	12.9
	Firm belonging to a university	23	7.2
	University spin-off firm	24	7.5
	Informal information exchange	86	27.0

Source: BR Survey, 2009, author's elaboration.

Table 8 presents the results or resources from university and research institutes important to firms' innovation. The highlighted relevance of intangible resources as result of interactive process is the first aspect to be noted - research results (113 firms). It means that the knowledge generation is a function of Brazilian university recognized by the selected group of firms that are capable to learn with them. Resources used in experiments strictly academic, are also important in the processes of innovation, as noted in the relevance of laboratories/metrology (98) pointed by a significative portion of firms. Other tangibles results from universities research as new techniques and instruments (67 firms) and prototypes (87 firms) are also important to firms' innovation.

Table 8 - Results and resources produced by university and research institutes important to firm's innovation, Brazil, 2009.

Results or resources	Moderately or Very Important	
Research Results	113	35.4%
Laboratories/Metrology	98	30.7%
Prototypes	87	27.3%
New techniques and instruments	67	21.0%

Source: BR Survey, 2009, author's elaboration.

The table 9 presents the reasons for firms' collaboration with university and research institutes and confirms the analysis that the Brazilian firms interacting with universities to solve production problems, but they are also engaged in more sophisticated interactions as research projects. In general the firms are looking for codified and tacit knowledge (technology transfer,

access to information and R&D trends, and various types of research activities), for test and routine services (use of labs, quality control, advice and consultancy for production) and also for human resource (students for future hiring).

Table 9 - Reasons for collaboration with university and research institutes, Brazil, 2009.

Reasons for collaboration	Moderately or Very Important	
University's technology transfer	89	27.8%
Tests required for the company's products and processes	89	27.9%
Use resources available at universities and research labs	86	26.9%
Outsource additional research, necessary to the firm's innovative activities	83	26.0%
Outsource researches that the firm can not do	83	26.1%
Search for technological advice or consultancy with researchers and/or teachers to solve problems related to production	81	25.4%
Increase firm's ability to find and absorb technological information	74	23.2%
Get information about engineers and scientists and/or R&D trends in science.	67	21.0%
Contact, as soon as possible, students for future hiring	45	14.1%
Help in quality control	37	11.6%

Source: BR Survey, 2009, author's elaboration.

5 FINAL CONSIDERATIONS

In Latin American countries one can find important differences of their National Innovation System (NIS) if compared to those of developed countries and using a narrow view of NIS will lead to a conclusion that innovation does not occur in most countries. However, following the suggestion of Lundvall *et al.* (2009) we can capture elements that simple ST&I indicators do not. That is the reason why we use a broad definition of NIS in this paper when trying to characterize the university-industry relations in Brazil. We believe that a careful analysis of the interaction of actors in Brazilian NIS is important and may give important clues on how to foster innovation because it is an interactive process and that is the reason why universities cannot be an isolated actor and must be integrated in the generation of innovation.

We proposed in this paper that Latin American countries have some peculiarities and many factors are embedded in the way new relevant knowledge is created and transferred to different actors. Norms and traditions in the region shape the relations among the actors. We showed hat most of the problems in the innovation system in the region are structural,and political and economic, historic and cultural specificities determined a specific institutional trajectory that affect the region's ability to innovate and compete in global markets. Brazil also suffers from the same problems; however, we found evidences that Brazil, somehow, has some particularities: a) new Government orientation in favor of ST&I policies; b) a relative increase in the number of innovative industrial firms in the past years; and c) Brazilian universities do more than consulting activities and routine services. We focused out attention in this paper to the particularity letter c.

We investigated the academic side of the U-I linkages, reporting results from a survey applied to research groups from universities and public institutes in Brazil. Answers from 1,005 research groups were analyzed according to the mode of interactions, results, benefits and channels for information exchange. We found that contrarily to "conventional Latin American wisdom," Brazilian universities do more than consulting activities and routine services (technical evaluations, project management, testing and engineering services). They are also engaged in R&D projects of short and long term.

The investigation about the firm's side reinforced the notion that this important dimension of NSI is characterized by a heterogeneous pattern. In fact, despite Brazilian firms interacting with universities to solve production problems, they are also engaged in more complex interactions as research projects.

Our best comprehension in this matter is that the vast geographical dimension of Brazil holds local innovation systems that contrast with the behavioral and cognitive patterns involved in innovation processes. Among the elements that might help in understanding those differences we can mention the focus of industrial policy in past decades. Besides that one, the size of firms, the sector of industrial activity and the regional differences associated to business culture, seem to be good points of deepening this research. In accordance to other surveys in the literature, U-I interactions in Brazil frequently occurs through "open science" channels (publications, meetings and conferences), and the "educational channel" (training), as these are channels of information directly related to the research and teaching roles of universities.

We also found that interactions with firms reinforce universities' mission of human resource training and generates new knowledge for universities (thesis, dissertation, publications and research projects). The key benefits reinforce these results as the principal ones are related to access to new knowledge or knowledge augmenting.

Finally, we highlight university knowledge as an important resource to solve problems in firms' innovative performance and also to suggest new products and devices as expressed in the results for industry - new products and artifacts, improvements of industrial processes, improvements in industrial products and new industrial process.

On the other hand Brazilian firms are also changing. They are increasingly involved in innovative activities as show by PINTEC, and also in more sophisticated interactions with university. They engaged in interactions with universities and research institutes looking for codified and tacit knowledge, for test and routine services and also for human resource. So, despite Brazilian firms interacting with universities to solve production problems, they are also engaged in more complex interactions as research projects.

REFERENCES

ALBUQUERQUE, E. M.. National systems of innovation and non-OCED countries: notes about a rudimentary and tentative "tipology". *Brazilian Journal of Political Economy*, vol. 19, n. 4 (76), october-november, p. 35-52, 1999

ALBUQUERQUE, E. M.; SILVA; L. A.; PÓVOA. L. M. C.. Diferenciação intersetorial na interação entre empresas e universidades no Brasil. *São Paulo em Perspectiva*. São Paulo. v. 19. n. 1. p. 95-104. 2005.

ALDANA, F. A. C.. La relación universidad-entorno socioeconómico y la innovación. *Revista Ingeniería e Investigación*, v. 26, n. 2, p. 94-101, 2006.

ALMEIDA, J. G.. *Alcance e lacunas da nova política industrial*. Texto para Discussão. IE/UNICAMP, n. 196, out. de 2011.

AROCENA, R.; SUTZ, J.. Knowledge, innovation and learning: systems and policies in the north and in the south. In: CASSIOLATO, J. E.; LASTRES, H. M. M.; MACIEL, M. L. (eds.) *Systems of Innovation and Development – Evidence from Brazil,* Edward Elgar, 2003.

AROCENA, R.; SUTZ, J.. Looking at national systems of innovation from the south. *Industry and Innovation*, v. 7, pp. 55-75, 2000.

ARZA, V.. Channels, benefits and risks of public-private interactions for knowledge transfer: conceptual framework inpired by Latin America. *Science and Public Policy*, v. 37, n. 7, aug. 2010, pp. 473-484.

ARZA, V.; VAZQUEZ, C.. Interactions between public research organisations and industry in Argentina. *Science and Public Policy*, v. 37, n. 7, aug. 2010, pp. 499-511.

BERNARDES, A. T.; ALBUQUERQUE, E.. Cross-over, thereshold, and interactions between science and technology: lessons for less-developed countries. *Research Policy*, v.32, p.865-885, 2003.

CANO, W.. América Latina: notas sobre a crise atual. *Revista Economia e Sociedade*, v. 18, n. 3, 2009.

CANO, W.; SILVA, A. L. G.. *Política industrial do governo Lula*. Texto para Discussão. IE/UNICAMP, n. 181, julho de 2010.

CARDOSO DE MELLO, J. M.. *O capitalismo tardio*. São Paulo Brasiliense, 1982.

CASSIOLATO, J. E.; LASTRES, H. M. M.. *Discussing innovation and development*: converging points between the Latin American school and the Innovation Systems perspective? GLOBELICS Working Paper Series, N. 08-02, 2008.

CEPAL, Comisión Económica para América Latina y el Caribe. *Panorama de la inserción internacional de America Latina y el Caribe*. Santiago: Cepal (relatórios anuales), 2006.

COHEN, W. M.; NELSON, R. R.; WALSH, J. P. The influence of Public Research on Industrial R&D. *Management Science*, v. 48, n.1, p.1-23, 2002.

CHIARINI, T.; VIEIRA, K. P.. Alinhamento das atividades de pesquisa científica e tecnológica realizadas pelas IES federais de Minas Gerais e as diretrizes da Política Industrial, Tecnológica e de Comércio Exterior PITCE. *Revista Brasileira de Inovação*, v. 10, p. 301-342, 2011.

DAGNINO, R.. Ciência e tecnologia no Brasil: o processo decisório e a comunidade de pesquisa. Campinas: Editora da Unicamp, 2007.

DUTRENIT, G.; ARZA, V..Channels and benefits of interactions between public research organisations and industry: comparing four Latin American countries. *Science and Public Policy*, v. 37, n. 7, aug. 2010, pp. 541-553.

DUTRENIT, G.; FUENTES, C.; TORRES, A.. Channels of interaction between public research organisations and industry and their benefits: evidence from Mexico. *Science and Public Policy*, v. 37, n. 7, aug. 2010, pp. 513-526.

EDQUIST,C.;HOMEMM, L.. Comparing national systems of innovation in Asia and Europe: theory and comparative framework. Chapter 1 In: EDQUIST,C.;HOMEMM, L. (eds.) Small Countries Innovation Systems, Globalization, Change and Policy in Asia and Europe.

ETZKOWITZ, H.. Bridging the gap: the evolution of industry-university links in the United States. In: BRANSCOMBS, L. M.; KODAMA, F.; FLORIDA, R. (eds.) *Industrializing Knowledge – University-Industry Linkages in Japan and the United States.* The MIT Press, p.203-233, 1999.

FAJNZYLBER, F.. *Industrialización en América Latina*. Mexico: Nueva Imagen, 1983.

FAJNZYLBER, F.. *La industrialización trunca de América Latina*: de la "caja negra" al "casillero vacio", Cepal, Cuadernos de la Cepal, n. 60, 1989.

FEIJÓ, C. A.; LAMONICA, M. T.. Importancia del sector industrial para el desarrollo de la economía brasileña. *Revista de la Cepal*, n. 107, agosto 2012, pp. 115-136.

FERNANDES, A.C.; SOUZA, B. C.; SILVA, A. S.; SUZIGAN, W.; CHAVES, C. V.; ALBUQUERQUE, E.. Academy-Industry links in Brazil: evidence about channels and benefits for firms and researchers. *Science and Public Policy*, v. 37, n. 7, aug. 2010, pp. 485-498.

FIORI, J. L.. O sistema interestatal capitalista no início do século XXI. In: FIORI, J. L.; MEDEIROS, C.; SERRANO, F.. *O mito do colapso do poder americano*. Rio de Janeiro: Record, 2008.

FORERO, P.. The impact of stronger intellectual property rights on science and technology in developing countries. *Research Policy*, vol. 35, pp. 808–824, 2006.

FURTADO, C.. *A economia latino-americana*. Rio de Janeiro: Paz e Terra, 1978.

FURTADO, C.. O subdesenvolvimento revisado. *Economia e Sociedade*, v. 01, ago. 1992, p. 05-19.

KLEVORICK, A. K *et al*. On the sources and significance of inter-industry differences in technological opportunities. *Research Policy*, v.24, n.2, p.185-205, March, 1995.

KOELLER, P.; GORDON, J. L.. The role of the State in National Systems of Innovation. *Nota Técnica RedeSist Projeto Brics*, 2009. Available at: <brics.redesist.ie.ufrj.br/proj_idrc/>. Acess on: 17/12/2011.

LEE, Y. S.. 'Technology transfer' and the reserch university: a search for boundaries of university-industry collaboration. *Research Policy*, v.25, p.843-863, 1996.

LUNA, M.. Las Universidades Públicas Estatales: Estratégias y Factores de Colaboración con las empresas. In: CASAS, R. (org.) *La formación de redes de conocimiento: una perspectiva regional desde México.* Instituto de Investigaciones Sociales- UNAM: Anthropos Editorial, 2001.

LUNDVALL, B. A.. *Innovation system research*: where it came from and where it might go. GLOBELICS Working Paper Series, N. 07-01, 2007.

LUNDVALL, B. A.; VANG, J.; JOSEPH, K. J., CHAMINADE, C.. Innovation system research and developing countries. In: LUNDVALL, B. A.; JOSEPH, K. J., CHAMINADE, C.; VANG, J.. *Handbook of innovation systems and developing countries*: building domestic capabilities in a global setting. Edward Elgar, Cheltenham, UK, 2009.

MALONEY, W. F.; PERRY, G.. Hacia una política de innovación eficiente en América Latina. *Revista de la Cepal*, n. 87, diciembre 2005, pp. 25-44.

MELLO,J. M. C.; MACULAN, A. M.; RENAULT, T.. *Brazilian Universities and their Contribution to Innovation and Development*. In: Bo Goransson; Claes Brundenius. (Org.). Developing Universities: The Changing Role of Academic Institutions in Development. Londres: Routledge/IDRC. 2009. v. . p. 1-25.

MEYER- KRAMER, F.; SCHMOCH, U.. Science-based technologies: university- industry interactions in four fields. *Research Policy,* v.27, p. 835-851, 1998.

NELSO, R.; WINTER, S.. *An evolutionary theory of economic change*. Cambridge: Harvard University Press, 1982.

NEVES, E. A.. Mudança institucional e custo de transferência internacional de tecnologia no Brasil. Dissertação de Mestrado. UNICAMP, IG/DPCT, 2002.

NIOSI, J.; SAVIOTTI, P.; BELLON, B.; CROW, M.. National systems of innovation: in search of a workable concept. *Technology in Society*, v. 15, pp. 207-227, 1993.

OECD, Organization for Economic Co-operation and Development. *Education at a Glance 2010:* OECD Indicators, 2010.

PERES, W.. El lento retorno de las políticas industriales en América Latina y el Caribe. *Revista de la CEPAL*, v. 88, 2006.

POSSAS, M.. Em direção a um paradigma microdinâmico: a abordagem neoschumpeteriana. In: AMADEO, E. (ed.). *Ensaios sobre economia política moderna*. São Paulo: Marco Zero, 1989.

POVOA, L. M. C.; MONSUETO, S. E.. Tamanho das empresas, interação com universidades e inovação. *Revista de Economia*, v. 37, n.3, p.7-21, 2011.

RANGA, L M.; DEBACKERE, K.; TUNZELMANN, N. V.. Entrepreneurial universities and the dynamics of academic knowledge production: a case study of basic vs. applied research in Belgium. *Scientometrics*, v.58, n.2, p.301-320, 2003.

RAPINI, M. S.; CHIARINI, T. ; BITTENCOURT, P. F.. *The University-Industry relations in a peripheral context*: Their contribution to knowledge generation and innovation in Brazil.. In: IV Congreso Anual de la Asociación de Economía para el Desarrollo de la Argentina, 2012, Buenos Aires. Memorias del IV Congreso Anual de la Asociación de Economía para el Desarrollo de la Argentina, 2012.

SCHARTINGER, D.; SHIBANY, A.; GASSLER, H. Interactive relations between universities and firms: empirical evidence for Austria. *Journal of Technology Transfer,* v.26, p.255-268, 2001.

SIEGEL, D.; WALDMAN, D.A.; ATWATER, L.; LINK, A.N.. Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *Journal of High Technology Management Research,* v.14, p. 111–133, 2003.

SILVA, R. B.. Um instrumental metodológico para a análise da relação universidade-governo nos países de capitalismo periférico. *Avaliação*, v. 17, n.2, p. 405-432, 2012.

SRINIVASA, S.; SUTZ, J.. Developing countries and innovation: Searching for a new analytical approach. *Technology in Society* 30, pp. 129–140, 2008.

SUNKEL, O.; PAZ, P.. *El subdesarrollo latinoamericano y la teoría del desarrollo*. Ed. Siglo XXI, 1973.

SUTZ, J.. The New Role of the University in the Productive Sector. In: ETZKOWITZ, H.; LEYDESDORFF, L. *Universities and the Global Knowledge Economy – A triple Helix of University- Industry- Government*. Printer: London e Washigton, 2000.

SUTZ, J.. The New Role of the University in the Productive Sector. IN: ETZKOWITZY, H.; LEYDESDORFF, L. (org) *Universities and the Global Knowledge Society*. InglaterraPinter , Londres, 1997, *p.* 11 - 21.

SUZIGAN, W.; ALBUQUERQUE, E. M.. *The underestimated role of universities for development:* notes on historical roots of Brazilian system of innovation. In: XVth World Economic History Congress. 2009. Utrecht. XVth World Economic History Congress. Utrecht : International Economic History Association. 2009.

SUZIGAN, W.; ALBUQUERQUE, E. M.. The underestimated role of universities for development. *Brazilian Journal of Political Economy*, v. 31, n. 1, p.3-30. Jan./Mar. 2011.

SUZIGAN, W.; RAPINI, M. S.; ALBUQUERQUE, E. M.. *A changing role for universities in the periphery*. Texto para Discussão. Cedeplar/UFMG, n. 420, Abril de 2011.

UNCTAD, United Nations Conference on Trade and Development. *La acumulación de capital, el Guillén económico y el cambio estructural*. New York: Unctad-UN, 2003.

VAN VIANEN, B. G.; MOED, H. F.; VAN RAAN, A. F. J.. An exploration of the science base of recent technology. *Research Policy*, v.19, p.61-81, 1990.