University and Industry Linkages in Brazil: Some Preliminary and Descriptive Results

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The main aim of this paper is to exam the patterns of university-industry linkages in Brazil. To do that, it is presented some preliminary and descriptive results from two main sources, the database from the Brazilian Research Council (CNPq), and some descriptive data from the Brazilian university survey. Even with these data was not enough to present and to discuss the pattern, it can show some interactions between university and firms in Brazil, especially the role played by the university in the creation and diffusion of knowledge among firms. The main results show that Brazilian university can play an important role among firms, not only by the rendering of services, which is a way to transfer codified knowledge, but also by the establishment of cooperative research, in which the knowledge involved are more tacit and requires close interaction between universities and firms.

Keywords: University-industry linkages, Innovation, Brazilian industry

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I. Introduction

The Brazilian economy presented a GDP around U.S.$ 1,843 billion in 2007, which results in a GDP per capita of U.S.$ 9,417. The total exports were around U.S.$ 160 billion in 2007 and the imports were U.S.$ 120 billion in the same year. The main exported products involved not only basic and semi manufactured goods, such as iron ore, oil, soybeans, meat, sugar, and pulp, but also manufactured goods, such as airplanes, cars and auto parts and cell phones.

In terms of S&T indicators, total expenditures on S&T accounts for an amount around 1% of GDP, in which private total expenditures were around 65% of total expenditure. Brazilian researchers published 18,915 academic papers in international referred journals in 2006, which correspond to 1.85% of the total publications. However, patents in the U.S. offices (USPTO) were just 333 in 2006, which results in a very small share of the world patents. In terms of regional distribution, it could be seem that there is a very unequal regional distribution of the economic activity and, mainly, S&T efforts, that are strongly concentrated in the Southern part of the country.[1]

As it is usual in developing country, in the Brazilian economy universities could play a very important role in the creation and diffusion of new knowledge among firms, as a way to promote and to foster economic development. As many authors says (such as Cohen *et al.* 2002; Mazzoleni and Nelson 2007), positive feedbacks between universities and firms could play an important role to economic development and to the catch up processes, as a way to create new knowledge to the firms and to strengthen the research at the universities.

As stated by Klevorick *et al.* (1995), by using data from the Yale survey, universities are a very important source of knowledge for the innovative efforts of firms, especially in industries in which new academic research findings are directly connected to industrial innovation. Nevertheless, in the case of developing countries, such as Brazil, this role of the university must be investigate, since the industrial structure of these countries didn't show the strong presence of firms in high-tech industries. In this way, in contrast to the role of the academic research in developed countries, in developing economies the university could

[1] Data of GDP and GDP per capita came from National Account (IBGE). Data on S&T Indicators came from Brazilian Ministry of Science and Technology (MCT).

have different characteristics and distinct patterns of interactions with firms.

In this way, this paper aims to show and to exam some characteristics of the patterns of university-industry linkages in Brazil. To do that, it is presented some preliminary and descriptive results from two main sources. First, the database from the Brazilian Research Council (CNPq), collected at the CNPq Directory of Research Groups in Brazilian universities. Second, some descriptive data from 1,005 answered questionnaires from the Brazilian university survey. These data was far from enough to present and to discuss a pattern of university-industry linkages in Brazil, but it can show some main, and preliminary, characteristics of the interactions between university and firms in Brazil, especially the role played by the university in the creation and diffusion of knowledge among firms. The paper is organized in 5 sections. Moreover this introduction (Section 1), it is presented some main methodological remarks (Section 2). After that, Section 3 shows the results from the research groups' data, based on CNPq Directory and Section 4 presents some results on the Brazilian university survey. At the end, it is presented some final remarks and a proposed research agenda.

II. Some Methodological Remarks

It is worthy to stress that the main results presented in this paper are essentially preliminary and descriptive, since the research on Brazilian university-industry linkages are still on-going. In the current stage of the development of the research, it was done the analysis of the database of the Brazilian Research Council (CNPq), collected at the CNPq Directory of Research Groups of Brazilian universities. This database allows the identification of 2,151 interactive research groups in Brazil, which became the population for the questionnaires. The questions were sent by e-mail to the leaders of the research groups, during May to September 2008, and it was received 1,005 answered questionnaires. These data, and the preliminary results that came from it, should be complemented by a survey of firms and by deeper case studies, which can be useful in the task of find the main characteristics of the university-industry linkages in Brazil.[2]

[2] The Brazilian team on the university-industry linkages is organized in a much decentralized way, according to the characteristics of the country. Each one of the main Brazilian states has its own local co-coordinator, in order to

The results presented on this paper, as pointed out, are preliminary and essentially descriptive, in two main fields. First, by the analysis of the CNPq Directory database, it could be possible to map the interactive research groups in Brazil and additionally, to identify the main important interactions between knowledge fields and industrial sectors. Second, the data collected and organized from the research groups' survey allows the identification of the main types of interaction, the results of the interaction and the main benefits for the research group. Both of these analyses are presented in the next sections.

III. Results from the CNPq Directory Database

The analysis of the information from de CNPq Directory allows the identification of some characteristics of the patterns of university-industry linkages in Brazil, and mainly the identification of the major interactive areas and industrial sectors. Besides this, the data provides the configuration of a list of firms that presented some kind of interaction with university.[3]

The CNPq Directory of Research Groups was developed by the Brazilian Research Council (CNPq), an institution linked to the Brazilian S&T Ministry (MCT), to gather and organize information regarding research activities in Brazil, by asking for the leader of the research groups information about their activities. Among this information, the research group leader is asked about interactions with firms and their main characteristics. This project was created in 1992, and the Brazilian Research Council did 7 censuses, in 1993, 1995, 1997, 2000, 2002, 2004, and 2006. In the first census in 1993 there were 4,402 research groups in 99 institutions. In 2004, it was 19,407 research groups in 375 institutions.[4] In general, the adherence to the CNPq Directory is increasing and it covers an important and representative share of the Brazilian scientific community.

The notion of "research group" adopted by the database is "a group

facilitate the collection of the data and to research the local, and different type, of university-industry linkages. The working out of the data was made by the coordination of the national team, that sum the data from the states.

[3] Main information about the CNPq Directory could be seen in the website (http://lattes.cnpq.br). Authors want to thank Herica Righi, who was responsible by the treatment of the data from the CNPq Directory.

[4] Data from the 2006 census was not available during the elaboration of this paper.

of researchers, students and technical support staff that is organized around the development of scientific research lines following an hierarchical ruled based in the expertise and in the technical-scientific competence." The group members usually share facilities and physical location. The database information are related to human resources, such as researchers, students and technical staff; main research lines; knowledge specificities; academic production, measured by scientific publications, patents, and artistic production; industrial sectors connected with the research groups activities; and patterns of interaction of the research group with firms. So, the unit of analysis of the CNPq Directory is the research group, its activities and localization.

The CNPq Directory gather information from all research institutions in Brazil, such as public universities, federal, state, and municipal; private universities; higher educational institutions, that are not universities and have at least one formal graduated course; public scientific research institutes; public technology institutes; R&D laboratories from state owned enterprises; non-governmental organizations permanently involved in scientific and technology research. Private enterprises and their R&D facilities and labs are not included in the CNPq Directory.

Since 2002, it was included in the CNPq Directory specific questions about university-industry linkages, which are an important source of information about the patterns of interaction between firms and universities in Brazil. Nevertheless, there are some methodological problems in the collection of data that should be pointed out. The main important lack in the database is that the adherence to the CNPq Directory is spontaneous and data is collected by self-declaration, without any consistency exam. In practice, this means that some researchers, leaders of their groups, give much importance to the database and insert a lot of information about the activities of the group and mainly, the characteristics of the interaction with firms. Meanwhile, other research groups didn't give the same importance and didn't insert too many information in the database. This became very clear in one of the case studies that were made during the development of the project, about a research group in the scientific area of Chemistry. The group showed a great number of interactions with firms, and some of them are continuous along time. However, the leader didn't insert any information about their linkages with industry. So, there is high possibility that the interactions between the research groups and firms are underestimated in the CNPq Directory database.[5]

In this paper, it was obtained the data from the Census of 2004. The

TABLE 1
REGIONAL DISTRIBUTION OF THE INTERACTIVE RESEARCH GROUPS AND FIRMS – BRAZIL, 2004

State	Interactive research group	Firms[1]	Density of interaction[2]
São Paulo	464	945	2.04
Rio Grande do Sul	265	426	1.61
Minas Gerais	226	423	1.87
Rio de Janeiro	259	343	1.32
Paraná	183	295	1.61
Santa Catarina	163	266	1.63
Bahia	111	159	1.43
Pernambuco	88	138	1.57
Distrito Federal	61	100	1.64
Ceará	51	71	1.39
Goiás	43	63	1.47
Pará	53	52	0.98
Paraíba	36	39	1.08
Rio Grande do Norte	23	38	1.65
Amazonas	28	35	1.25
Espírito Santo	16	26	1.63
Mato Grosso	19	18	0.95
Sergipe	15	14	0.93
Maranhão	14	14	1.00
Alagoas	10	13	1.30
Tocantins	6	8	1.33
Acre	1	7	7.00
Mato Grosso do Sul	11	4	0.36
Piauí	3	3	1.00
Roraima	2	2	1.00
Total	464	945	2.04

Source: CNPq Directory database, Census 2004.
Notes: 1) The sum of the interactive firms is higher than the total of firms because firm could interact with research groups in more than one state.
2) Density of interactions is calculated by the division of the number of firms and the number of interactive groups.

[5] This case study was made with the research group called LIEC (Interdisciplinary Laboratory of Electrochecimal and Ceramics), a joint group between the Chemical Institute of UNESP (State University of Sao Paulo) and UFSCar (Federal University of Sao Carlos). It will be publish in a book with some of the main experiences of university-industry linkages in the Brazilian states. During an interview with the research group leader, he said that there is no strong stimulus to fill the form of the CNPq Directory.

main variable used to build a preliminary map of the university-industry linkages in Brazil were: i) the research group scientific and engineering fields; ii) the firms that the research groups interact and its industrial sector (ISIC 3); and iii) the main types of relationship between the research group and firms. Among the 19,470 research groups in the Census of the CNPq Directory database of 2004, 2,151 groups declared that they have interactions with 3,068 firms. So, even with the mentioned underestimate data, 11% of the research groups in the CNPq Directory database declared that they interact with firms. The regional distribution of the interactive research groups, and firms, is shown at Table 1.

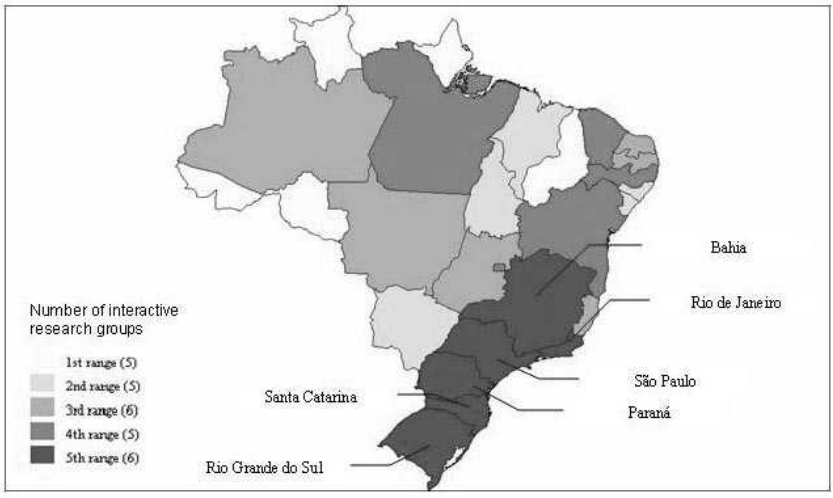
As Table 1 show, there is a strong regional concentration of the interactive research groups, and of the firms, in some states, mainly in the state of Sao Paulo, which represent 21% of the total interactive groups and 31% of the total of firms. Despite this, it should be mention that this concentration of the interactive groups is lower than the concentration of other economic and S&T indicators, since the state of Sao Paulo is responsible for 34% of the Brazilian GDP, 43% of the manufacturing product, 46% of the total of the patents in the Brazilian office (INPI), 48% of the PhD formation and 51% of the total Brazilian publication in international journals.[6]

Other important states are Rio Grande do Sul, 12% of total interactive groups and 14% of firms; Minas Gerais, 11% of groups and 14% of firms; Rio de Janeiro, 12% of groups and 11% of firms; Paraná, 9% of groups and 10% of firms; and Santa Catarina, 8% of groups and 9% of firms. In convergence to the regional distribution of GDP, all these states are located in the South of Brazil, as shown in Figure 1.

Taking the main scientific areas, the area that presents more interaction with firms is Engineering, with counts to 587 interactive research groups and 1,373 enterprises, followed by Agrarian Sciences, with 392 interactive groups and 692 firms (Table 2).

Two main points could be emphasized from these data. First, the importance of the Engineering. As mentioned by many authors, such as Nelson (1996) and Metcalfe (2003), the main role of the engineering in the economy is to disseminate new knowledge from the other scien-

[6] Data on GDP came from the IBGE Regional Accounts (Brazilian Institute of Economic Statistics); and data on S&T indicators came from the unpublished FAPESP, *Science, Technology and Innovation Indicators in the State of São Paulo/ Brazil* - 2008.



Source: CNPq Directory database, Census 2004.

FIGURE 1

REGIONAL DISTRIBUTION OF INTERACTIVE RESEARCH GROUPS – BRAZIL, 2004.

TABLE 2

MAIN SCIENCE & ENGINEERING FIELDS OF THE INTERACTIVE RESEARCH GROUPS AND FIRMS – BRAZIL, 2004

Scientific & Engineering fields	Interactive Research groups	Firms*
Engineering	587	1,373
Agrarian Sciences	392	692
Natural and Earth Sciences	314	477
Biology	199	314
Healthy Sciences	215	279
Social Applied Sciences	118	193
Human Sciences	97	149
Linguistics and Arts	20	22
N.A.	209	1
Total	2,151	3,067

Source: CNPq Directory database, Census 2004.

Note: * Firms that have more than one interaction could be classified in more than one S&E field.

tific fields to its application in new products and new manufacturing process. Therefore, the data from the CNPq Directory shows that in Brazil the different fields of engineering are playing this role through the interaction and linkages with firms. In addition, it is important to qualify the type of these linkages, especially if these interactions are important tools for the creation and diffusion of new knowledge among firms.

The second point is the high share of Agrarian Sciences' interactive groups and firms, which shows the importance of the academic research as a source of knowledge for the agricultural firms. Traditionally, the Brazilian agriculture has presented very high performance in terms of production and innovation, as it can be seen by its important share in the international market. The data collected from the CNPq Directory database shows that the academic research and the services rendered by the university could play an important role for this high performance.

The last result on the exam of the CNPq Directory database is the identification of the more important industrial sectors in which is possible to see university-industry linkages (Table 3).

Table 3 summarizes the main points of interactions between Scientific and Engineering fields and industrial sectors, by showing the number of interactive research groups in certain S&E field and the number of firms in each industrial sector. For example, there are 42 firms in Agricultural that interact with 49 research groups on Agronomy. Other industrial sectors that could be pointed out are Chemical, which interact with Metallurgy and Material Engineering, Chemical Engineering and Chemistry; Electricity, which interacts with Electrical Engineering; Food and Beverage, with interactions with Food Technology; Human Healthy, with Medicine; Computer Equipment, with Electrical Engineering; and Software, with Computing.[7]

This descriptive picture can help in the understanding of some patterns of interaction between universities and firms in Brazil. The existence of university-industry linkages shows that there are some research groups that could play an important role in the creation and diffusion of new knowledge among firms. Nevertheless, it is necessary to qualify these interactions, in terms of their type and density. For

[7] It is important to say that some of these points of interaction between S&E fields and industrial sectors are results of the existence of Brazilian laws that link fiscal benefits with R&D expenditures, part of it jointed with universities and research institutes. This is the case of Computer Equipment, Software and Electricity.

TABLE 3

MAIN POINTS OF INTERACTION BETWEEN SCIENTIFIC & ENGINEERING FIELDS AND INDUSTRIAL SECTORS – BRAZIL, 2004

Industry	Scientific & Engineering Field	Firms	Interactive research groups
Agricultural	Agronomy	42	49
Food and Beverage	Food Technology	46	27
Chemical	Metallurgy and Material Engineering	38	15
	Chemical Engineering	38	24
	Chemicals	30	26
Pharmaceutical	Pharmacology & Pharmaceutical	47	25
Metallurgy	Metallurgy and Material Engineering	42	32
Computer Eq.	Electrical Engineering	39	28
Automotive	Metallurgy and Material Engineering	30	17
Electricity	Electrical Engineering	56	53
Software	Computing	39	31
Human Healthy	Medicine	32	41

Source: CNPq Directory database, Census 2004.

example, there are important differences in terms of knowledge creation and diffusion if the linkage is based in a simple service rendering, such as a laboratory test, or if both university and industry maintain joint and collaborative research projects, in which they interact and exchange not only information, but also knowledge.

IV. The University Survey: Some Descriptive Results

In order to gather information about the types of interaction with firms, it was done a huge survey with the leaders of the interactive research groups. This survey is an additional step for a better understanding of the role of the university in the creation and diffusion of knowledge among firms.

Foremost, it is necessary to point out some methodological remarks. To do the survey with the interactive research groups, it was constructed, based on the information of the CNPq Directory, a database with 2,151 interactive research groups. This is the total of research groups in the CNPq Directory that declare any kind of interactions with firms and it became the population for the survey. Since the database had information about the electronic address of the group leader, it

was sent for each one a small questionnaire, asking him about the characteristics of the interaction of the research group with firms.[8] The questionnaire comprised some key questions about the nature of the interactions with firms, such as: types of relationship; main results from the interaction for the research group; benefits for the research group that came from the interaction; main difficulties with the interaction with firms; and channels of information flow from the research group to firms for transferring knowledge. Furthermore, the questionnaire aims to investigate how the researchers distinguish the interactions with firms according to their industrial sectors and there were some questions to ask for other aspects of the interactions, such as their impact on the group's research activities and the starting point of the initiative for the interaction. The submission of the questionnaire took six months, from May to September of 2008. At the end, it was received 1,005 answered questionnaires.

As expected, there wasn't a uniform distribution of the answered questionnaires among the scientific and engineering fields. The main areas that composed the database from the university survey were: Agronomy, 86 answered questionnaires; Electrical Engineering (62); Metallurgy and Material Engineering (57); Civil Engineering (46); Computing Sciences (44); Mechanical Engineering (44); Chemistry (41); Geosciences (37); and Medicine (35). Nevertheless, it is important to point out that the main areas that were identified, by the analysis of the CNPq Directory database that had more important interactions with firms, was well covered by the university survey. In this way, in convergence to the main objective of the paper, the results can contribute to a better understanding of the patterns of university-industry linkages.

In regards to the types of relationship between university and firms, it could be seen that the main important types are short-term R&D cooperative projects, consultancy and training (Table 4).[9]

[8] It is important to mention that the preparation of the questionnaire for the survey was done with the collaboration of the researchers of the Brazilian team and, after that, on rounds that involved Latin American researches and Asian and African groups. At the end, it was possible to build a single questionnaire for all countries involved in the research project on university-industry linkages. Some results from the application of the questionnaire are presented in this volume (Joseph and Abraham, 2009; Eun, 2009; Rasiah and Govindaraju, 2009; and Eom and Lee, 2009)

[9] Many questions employed the Likert scale to identify the importance for the research interactive group leader of each statement, by asking him to mark the best between "no importance" to "very important." In the tables showed in the

TABLE 4

TYPES OF RELATIONSHIP WITH FIRMS, BETWEEN RESEARCH INTERACTIVE GROUPS AND FIRMS, ACCORDING TO THE IMPORTANCE OF THAT TYPE OF RELATIONSHIP TO THE GROUP'S RESEARCH ACTIVITIES (ANSWERING MODERATELY IMPORTANT AND VERY IMPORTANT)

Types of relationship	Moderately or very Important	%
Short-term R&D collaborative projects	689	68.6
Consultancy	679	67.6
Training	630	62.7
Technical evaluation, project management	569	56.6
R&D projects that complements innovative activities in firms	542	53.9
Long-term R&D collaborative projects	514	51.1
Temporary personnel interchange	513	51.0
Technology transfer (licensing)	479	47.7
Tests	382	38.0
R&D projects that substitutes innovative activities in firms	374	37.2
Others	78	7.8

Source: BR University Survey, 2008.

The more important type of interaction with firms is the short-term R&D collaborative projects, which is characterized by the immediate use of the results of the research. Despite the concern with short-term results, which is not a general characteristic of the R&D efforts, this kind of collaboration involves bidirectional flows of interactions between university and industry, because normally it absorb researchers from the firm's R&D facilities and researchers of the university. So, in this kind of linkages, the interaction between university and firms is an important way for the creation and diffusion of knowledge, since it can create bidirectional flows of information and knowledge.

The next two more important, however, are not collaborative research projects but typical services that are rendered by the university, such as consultancy and training. These kinds of services have, in general, a unidirectional way of interaction, since they are characterize by a simple service rendering by the university to the firms. In this way, its capacity to create and diffuse knowledge for both the firm and the

paper, it was got the sum of the answers "moderately important" and "very important." In some question, the leader was asked to put the most important effect.

TABLE 5

MAIN RESULTS WITH FIRMS, ACCORDING TO THE IMPORTANCE OF THAT RESULT TO THE GROUP'S RESEARCH ACTIVITIES (ANSWERING MODERATELY IMPORTANT AND VERY IMPORTANT; AND THE MOST IMPORTANT)

	Moderately or very Important	%	The most important	%
New research projects	848	84.4	74	11.9
Human resources formation	830	82.6	140	22.4
Thesis and dissertation	823	81.9	79	12.7
Publications	806	80.2	60	9.6
New scientific findings	605	60.2	55	8.8
New products and devices	587	58.4	66	10.6
Improvements in industrial process	499	49.7	37	5.9
Improvements in industrial products	469	46.7	20	3.2
New industrial process	464	46.2	36	5.8
Patents	454	45.2	30	4.8
Software	332	33.0	8	1.3
Spin-offs firms	244	24.3	11	1.8
Others	29	2.9	7	1.1

Source: BR University Survey, 2008.

university is very narrow. In this way, it is very important to do more deeply exam on the type of interaction between university and firms and the flows of knowledge related in these relations. More intensive interactions between firms and university could generate denser, and bidirectional, flows of knowledge, which can benefit not only firms but also university.

Other result from the university survey is the main result for the research group of the interaction with firms (Table 5).

According to the leaders of the research group, the main results of the interaction are new research projects, which are considered very or moderately important to 84.4% of the respondents. This is a very interesting result because it shows that the interaction with firms can create new knowledge at the university, since the interaction can result in the creation of new research projects, because of its capacity to build new research questions. Formation of human resources is the second more important result for the research group (82.6% of respondents) and it was pointed that this is the most important result (22.4% of respondents, with no double accounting). This makes reference for the main objective of the university, which is formation of high qualified labor force, but in this case the formation of human

resources is a result of the strengthen university-industry linkages, with positive effects to the creation of knowledge. Other important results are typical research products, such as thesis, dissertation and publication in academic journals, which emerges from the interaction with firms. In sequence, less important for the research groups, are scientific discoveries, pointed as very or moderately important for 60.2% of the respondents; new products and devices (58.4%); improvements in industrial process (49.7%); improvements in industrial products (46.7%). Some results of linkage university-industry, that are pointed out in the literature as very important, such as patents, software and spin-offs firms, received less attention of the research group leaders, as it can be seen in the low percentage of very and moderately important.

To deep this results it will be necessary to link the type of the relation between firms and university to the main results of the interaction. By this way, it will be possible to exam the main effects of the different types of interaction in the creation and diffusion of knowledge through the interaction. In addition, it will be also interesting to get the firms' perception for the main results of the interaction, in which will be probably find different results.[10]

Another important set of findings of the university survey in Brazil is regard to the benefits for the research group of the interaction with firms. In general, research group leaders evaluate in a positive manner the interaction with firms (Table 6).

The main benefit of the interaction with firms that was pointed out by research groups leaders are new research projects, as it was signed by 85.9% of the respondents as very or moderately important. It is important to mention that new research projects were also considered by the leaders the main benefit for the research group that came from the interaction with firms. The second more important benefit is knowledge or information exchange, which was considered very or moderately important by 81.8% of the respondents. This result show the role of the university-industry linkages not only for the creation and diffusion of knowledge inside firms, but also the interaction with firms can contribute to the knowledge accumulation for the research group. In this way, it can conclude that the interaction with firms

[10] In the questionnaire for the firms, there is a question that asks for the firm's representative which are the most important results of the interaction with university. This will allow an interesting comparison between the two views of relationship.

TABLE 6

BENEFITS FOR THE GROUP FROM INTERACTION WITH FIRMS, ACCORDING TO THE IMPORTANCE OF THAT BENEFIT TO THE GROUP'S RESEARCH ACTIVITIES (ANSWERING MODERATELY IMPORTANT AND VERY IMPORTANT; AND THE MOST IMPORTANT)

	Moderately or very Important	%	The most important	%
New research projects	863	85.9	151	24.1
Knowledge or information interchange	822	81.8	143	22.8
Insights for new collaborative research projects	820	81.6	85	13.6
Access to new networks	727	72.3	40	6.4
Reputation	710	70.6	19	3.0
Material input for research	705	70.1	50	8.0
Financial resource	702	69.9	94	15.0
Others	26	2.6	1	0.2

Source: BR University Survey, 2008.

plays an important role for the group research performance, in a bidirectional way to exchange information and knowledge. The third more important benefit is the insights for new collaboration research projects, which is very or moderately important for 81.6% of the respondents. This result can strengthen the role of the interaction to the creation new research questions for the university researchers and, in consequence, to the creation of knowledge. Meanwhile, these results must be deepener, in the way to evaluate the role of the interaction with firms for the creation of knowledge from the academic research, in a bidirectional way to exchange information and knowledge.

Other interesting result is the importance of financial resources for the group. Even though the financial resources were considered very or moderately important for a relatively lower share of the research groups (last ranked and 69.9% of respondents), 15% of the leaders said that financial resources were the most important benefit for the research group. It is possible, in order to institutional reasons, related to the difficult to officially recognize the relation with firms, that most of the respondents underestimate the importance of financial resources for the research group.[11]

[11] It is possible that some research group leaders didn't answer correctly the importance of financial resources for the group, probably because they got

TABLE 7

CHANNELS OF INFORMATION BETWEEN RESEARCH GROUPS AND FIRMS, ACCORDING TO THE IMPORTANCE OF THAT CHANNEL OF INFORMATION FOR TRANSFERRING KNOWLEDGE FROM THE RESEARCH GROUP TOWARDS FIRMS (ANSWERING MODERATELY IMPORTANT AND VERY IMPORTANT; AND THE MOST IMPORTANT)

	Moderately or very Important	%	The most important	%
Publications and reports	753	74.9	85	15.2
Research contracts	752	74.8	97	17.3
Public conferences and meetings	747	74.3	64	11.4
Training	713	70.9	33	5.9
R&D cooperative projects	709	70.5	106	18.9
Informal information exchange	663	66.0	23	4.1
Recently hired graduates	586	58.3	17	3.0
Temporary personnel exchange	534	53.1	14	2.5
Individual consultancy	524	52.1	21	3.8
Engagement in networks with firms	462	46.0	29	5.2
Patents	431	42.9	14	2.5
Science parks	403	40.1	10	1.8
Incubators	399	39.7	9	1.6
Licensed technology	388	38.6	4	0.7
Others	22	2.2	6	1.1

Source: BR University Survey, 2008.

In regards to the main channels of information for transferring knowledge from university to firms, the main important channel were publications and reports, which was considered very or moderately important to 74.9% of the respondents; followed very closely by research contracts, 74.8% of respondents; by public conferences and meetings, 74.3%; training, 70.9%; R&D cooperative projects, 70.5%; and informal contacts, 66%. R&D cooperative projects was considered the most important channel by 18.9% of the respondents (Table 7).

It is interesting to point out that among these main channels of information some of them are channels that transmit codified knowledge generated in the university, such as publications and reports and public conferences and meeting. Nevertheless, there are some channels of information that are intrinsic ways to transfer tacit knowledge, such as research contracts, training, R&D cooperative projects, and informal

afraid to the institutional reaction.

contacts. This could mean that an important share of university-industry linkages is based in the exchange of tacit knowledge, probably in a bidirectional way of interaction. In addition, firms can use more than one channel of information to exchange knowledge with the university, since they can take part at conferences and do research at academic journals and other forms of publication, at the same time they can interact to university in other ways of exchange tacit knowledge, such as R&D cooperative projects. However, this is a very important research question that must be deeper for a better understanding of the patterns of university-industry linkages in Brazil.

Other interesting result on the main channels of information to exchange knowledge between firms and university is that the "new channels" of university-industry linkages, such as spinoffs firms, business incubators or science parks, was considered with very low importance to the respondents. This could mean that, in Brazilian experience, this kind of practice of technological policy should not have the desirable effects, especially by comparing with the high amount of resources that was dedicated to those experiences in the last years. Meanwhile, this is a research question that needs to be deeper in order to make a better evaluation of the role of these channels of information to the creation and diffusion of knowledge.

Other results from the university survey were in terms of the initiative to establish the interaction (Table 8).

In general, the main important initiative is due to the researcher, which was the main responsible for the interaction for 70.6% of the respondents. In other way, 46.5% of them, the responsible initiative was the firm and in 42.2% the initiative was shared by the researcher and firm.[12] It is interesting to mention the very limited role of the university and its Technology Transfer Offices (TTO) to foster university-industry linkages, since only 10% of respondents had pointed out these institutions as responsible for the initiative to establish interaction with the research group, even though many Brazilian universities had created their own technology transfer offices in order to make easier the linkage to firms. So, it is very interesting to make a deeper research on the role of these offices, through the investigation of their characteristics

[12] Two methodological comments should be added to this point. First, it is important to remember that the respondents were the leaders of the research groups, which could be created a selection bias on the sample of respondents. Second, the respondents could be mentioned more than one interaction with firms, which justify the sum be higher to 100%.

TABLE 8
INITIATIVE TO ESTABLISH THE INTERACTION WITH FIRMS

	Number of respondents*	%
Researcher	710	70.6
Firm	467	46.5
Both (Shared initiative)	424	42.2
Research group	323	32.1
University student hired by the firm	202	20.1
University institutional mechanisms for technological transfer (TTOs)	100	10.0
Spin-off of a group member	51	5.1
Ex-researcher initiative	40	4.0
Other	19	1.9

Source: BR University Survey, 2008.
Note: * It was possible to mark more than one option.

and the linkages that were established by them with firms.

Therefore, these descriptive, and preliminary, data on the patterns of interaction between university and firms show that Brazilian university can play an important role in the creation and diffusion of knowledge among firms, not only by the rendering of services by the university, which is a way to transfer more codified knowledge, but also by the establishment of cooperative research projects, in which the knowledge involved are more tacit and requires more close interaction between universities and firms.

V. Final Remarks and Research Agenda

In order to exam the patterns of university-industry linkages in Brazil, this paper presented some preliminary and descriptive results from two main sources, the analysis from the database of the CNPq Directory and the analysis of the data from 1,005 answered questionnaires from the Brazilian university survey. The main results show that, in general, there is an important role played by the university and the academic research in the creation and diffusion of new knowledge among firms. In general, the analysis of the data shows that the interaction between universities and firms can benefit both firms, as an important source for the innovative process insides enterprises, and university, though the creation of new research projects and new

investigation questions.

The interactions between university and firms in Brazil is characterized both by the transmission of typical codified knowledge, for example by rendering of services and training, and by the creation of bidirectional flows of information and knowledge, through collaborative R&D projects that involves researchers from the R&D facilities at the firm and researchers from the university.

Behind these general findings, there are some research questions that are not answered yet, which suggests the opening of a major research agenda to investigate the patterns of interaction between university and firms.

The first one is regards on a deeper exam on the type of interaction between university and firms and the characteristics of the flows of information and knowledge that emerges from the linkages. Even though it must be recognized the important role of the university in the diffusion of codified knowledge especially in developing countries such as in Brazil, some findings of the analysis of the data show that there is considerable number of collaborative research projects. In this type of project, which is associated to a certain pattern of interaction university-industry, the linkage can generate strong bidirectional flows of information and knowledge, which can benefit not only the firms, but also the academic research.

Another point that needs a deeper investigation is the association between the results of the interaction university-industry and the type of the relation between them. It is possible to assume that denser linkages between university and firms can produce better results both for the firm and for the university. Nevertheless, data analyzed in this paper can not give a definite answer for this question, what justify the need to deep the exam of the types of these relationship.

Other question that needs a better exam is the relation between the types of channels of information between university and firms and the pattern of knowledge exchange among them. A deep exam of the channel of information for the transferring knowledge from university to firm could help in the comprehension of the characteristics of the knowledge that is sharing among university and firms.

Moreover, another research question about the linkages university-industry in Brazil is regard to science and technology policy, since there are numerous policy measures towards the creation of mechanisms to stimulate knowledge sharing between university and firms, such as finance for spinoffs firms, business incubators and science parks.

The results of the analysis of the data in this paper show that these mechanisms have very low importance to foster interaction between university and firms. This is a very strong, and polemic, conclusion since this is some important measures of science, technology and industrial policy in Brazil to support this kind of mechanism. Furthermore, the same question could be made to the technology transfer office (TTO) of the universities. These offices were created to foster and to stimulate the transferring knowledge from university to firms. However, the results of the analysis presented in this paper show that this kind of mechanism is rarely employed both by the university and by the firms to create or to strengthen the linkages between university and firms.

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References

Cohen, W., Nelson, R., and Walsh, J. "Links and Impacts: The Influence of Public R&D on Industrial Research." *Management Science* 48 (No. 1 2002): 1-23.

Eom Boo-Youg and Lee Geun "Modes of Knowledge Transfer from PROs and Firm Performance: The Case of Korea" *Seoul Journal of Economics* 22 (No. 4 2009): 499-528.

Eun Jong-Hak "China's Horizontal University-Industry Linkage: Where From and Where To" *Seoul Journal of Economics* 22 (No. 4 2009): 445-66.

Joseph. K. J., and Abraham Vinoj "University–Industry Interactions and Innovation in India: Patterns, Determinants and Effects in select industries" *Seoul Journal of Economics* 22 (No. 4 2009): 467-98.

Klevorick, A., Levin, R., Nelson, R., and Winter, S. "On the Sources and Significance of Inter-industry Differences in Technological Opportunities." *Research Policy* 24 (No. 2 1995): 185-205.

Mazzoleni, R., and Nelson, R. "Public Research Institutions and Economic Catch-up." *Research Policy* 36 (No. 10 2007): 1512-18.

Metcalfe, S. "Equilibrium and Evolutionary Foundations of Competition and Technology Policy: New Perspectives on the Division of Labor and the Innovation Process." *Revista Brasileira de Inovação* 2 (No. 1 2003): 111-46.

Nelson, R. *The Sources of Economic Growth*. Cambridge, Mass.: Harvard University Press, 1996.

Rasiah Rajah and Govindaraju Chandran VGR "University-Industry Linkages in Thailand: Successes, Failures and Lessons Learned for Other Developing Countries" *Seoul Journal of Economics* 22 (No. 4 2009): 529-50.