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Collaboration with university and the innovative activities of Brazilian firms

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Abstract

This paper aims at mapping universityindustry interaction and collaboration in Brazil. Using indepth interviews to a sample of research groups at universities and at public research organisations, we find that collaboration with industry is mostly set to support the development of new products and processes, and to a lesser extent, training of firms' employees and the industrial use of university's infrastructures. Universityindustry collaborative projects tend to be initiated by firms or by academic researchers, who came out with a specific proposal for the improvement of processes or the market position of the firm. Finally, academic researchers in Brazil seem to have a more entrepreneurial attitude towards collaboration with industry than in developed countries.

1. Introduction

In Brazil, the science and technology infrastructure has been developed since the 1940s, as the industrialisation of the country was proceeding (Velho and Saenz, 2002). Still, connections between university research activities and industrial innovative development seem to be very loose (Velho and Saenz, 2002; Dagnino and Gomes, 2003). Brazilian policymakers are increasingly concerned with supporting the technological capabilities of their firms, especially the development of hightechnology industries (Brazilian Government, 2003). Following the innovation policies of developed countries, great public efforts are put on fostering universityindustry interaction and collaboration (OECD, 2002; Brazilian Government, 2003).

Despite, universityindustry interaction has attracted the attention of several researchers; few studies have explored the pattern and impact of this cooperation in new industrialised countries, and in particular in Brazil. However, policy replication seems to be a good receipt for policy failure (Najmabadi and Lall, 1995; Goldman et al., 1997). Therefore, the understanding of the motivations, impact and forms in which this universityindustry collaboration is organised by universities in Brazil is required.

This paper aims at mapping universityindustry interaction and collaboration in Brazil. In particular, we aim at exploring the motivations and characteristics of universityindustry cooperation in Brazil as well as how universities organise and manage cooperation with industry. Using data collected through facetoface interviews with the coordinators of research groups, at universities and public research organisations (PROs), we will explore the objectives for collaboration as well as the forms by which this collaboration is organised and managed by universities. In particular, we will focus on universityindustry collaboration in Physic and Mathematics, which seem to the most important disciplines for industrial researchers (Bodas Freitas and Bekkers, 2007), for the development of industrial innovations in biotechnology, nanotechnology, renewal energies and information and communication technologies.

This paper shows that university industry collaboration is mostly set to support the development of new products and processes, and to a lesser extent training firms' employees and the industrial use of university's infrastructures. Moreover, collaborative projects tend to be initiated by firms or by academic researchers, who came out with a specific proposal for the firm to improve their processes or market position. Still, public calls for collaborative research funds and postgraduate research seem also important mechanisms for setting up a collaborative project. Papers and postgraduation thesis, followed by patents and new products to the market are the most often referred results of collaborative projects with industry. Additionally, academic researchers in Brazil seem to have a more entrepreneurial attitude towards collaboration with industry than in developed countries (Lee, 2000; Lam, 2005). Since, development of new knowledge and access to research funds, as motivations for collaboration with industry, come after development and transfer of new technologies and support for the innovative activities of firms.

This paper is organised as follow. Section 2 reviews the literature on the objectives and impact of collaboration for research and development (R&D) and in particular of universityindustry collaboration. Section 3 describes the data and methodologies used for exploring the characteristics of universityindustry collaboration in Brazil. Section 4 presents the results of the empirical analyses on the motivations, the forms in which interaction and collaboration with industry is organised and managed as well as their impact for industrial firms and for universities. Section 5 concludes the paper.

2. UniversityIndustry collaboration

Collaboration for R&D with external partners seems to be a strategy for sharing costs and pooling risks to engage in an uncertain innovative activity (Hagedoorn, 1996; Hagedoorn et al., 2000; Caloghirou et al., 2003). Moreover, given the difficulty of accessing external knowledge, collaboration is a good form of developing capabilities, learning and acquiring knowledge and technologies. Indeed, Belderbos et al. (2004a) find that firms tend to engage in R&D cooperation with partners, which they consider useful as source of information to innovate.

Additionally, R&D collaboration allows accessing external complementary resources, which is fundamental, according to resourcebased perspective of the firm, to react quicker to market and technology changes as well as to accelerate the process of developing and introducing new products to the market. Participation in R&D collaboration might permit to create an option in the future use of new technologies and knowledge, especially in uncertain fields with high technological and market opportunities, and potential growth (Hagedoorn, 1996; Caloghirou et al., 2003). Moreover, being involved in good R&D collaborations might permit firms to secure early access to resources, and market, as well as political influence (Fritsch and Lukas, 2001; Caloghirou et al., 2003; Mioti and Sachwald, 2003).

Thus, besides allowing firms to explore economies of scale, R&D collaboration may permit firms to access new or complementary resources and skills, keep up with evolution of scientific knowledge, improve their technological and organisational capabilities, develop new products, and create new technological learning options on future technologies (Hagedoorn et al., 2000; Fritsch and Lukas, 2001; Caloghirou et al., 2003). Hence, firms seem to collaborate for R&D to reduce uncertainty inherent from the innovation process as well as to expand their markets (Tether, 2002, p. 965). Its importance seems to be increased as the technological interdisciplinarity and complexity as well as competitive pressures to shorten product life increased (Hagedoorn, 1996; Caloghirou et al., 2003).

Engagement in R&D collaboration seems biased towards large firms, firms in high-technology industries, which invest intensively in R&D (Hagedoorn et al., 2000; Fritsch and Lukas, 2001; Tether 2002; Mioti and Sachwald, 2003). In particular, the more firms aims the development of new market products, the more likely are firms to cooperate (Fritsch and Lukas, 2001; Tether, 2002; Monjon and Waelboreck, 2003). Benefits from R&D collaboration are found to be higher when firms are not

competing for the introduction of a new technology or product, but their cooperative research relates to the existing activities of firms. Additionally, collaboration is expected to be successful, the lesser problems of knowledge appropriation between the partners and the higher the efforts put on learning from different channels (Hagedoorn et al., 2000; Caloghirou et al., 2003).

The objectives and motivations for firms to engage in collaboration with specific partners seem related to type of complementarity that firms look for (Miotti and Sachwald, 2003; Belderbos et al., 2004b). In particular, for industrial firms, cooperation with universities and PROs seems especially aimed at accessing new knowledge and skilled labour, especially highly qualified engineers, whose capabilities can be tested during the collaborative project (Balcony and Laboranti, 2006, Lam, 2005; Tether, 2002). Indeed, Adams et al. (2001) find that firms search for membership on industryuniversity cooperative research centres mainly due to the importance of faculty consulting and of coauthorship with university faculty as well as a way to perform joint research and hiring of graduate students. Moreover, Lee (2000) shows that industry search for university collaboration for getting support in product development as well as for accessing new knowledge and discoveries through seminars and workshops.

Therefore, research projects involving collaboration with universities seem to be larger and closer to “new” science than are others, and consequently report unproductive costs and less likely to develop and commercialize technology sooner than expected (Hall et al., 2001). Either the university partner was chosen in anticipation of the difficulties or it permitted a greater awareness of the difficulties. Still, prior experience working with a university decreases significantly the difficulty of acquiring and assimilating basic knowledge and reduces the expectation of early commercialization (Hall et al., 2001).

The main objectives of industrial firms to engage in collaboration with university are research related to existing product line, exploratory research in search of new products, instrumentation and technical problem solving, and design of prototypes (Lee, 2000). In particular, firms increasingly engage in collaborative projects with universities to develop interdisciplinary scientific capabilities for solving complex problems (Lam 2005). In Brazil, collaboration between Brazilian research groups and industry seems particularly important to support firms in the general definition of their development projects (Rapini, 2007). Additionally, firms collaborate with university to maintain or to establish direct personal links with top professors (Lee, 2000; Balcony and Laboranti, 2006). Focusing on five indepth case studies carried out in sciencebased firms in the UK, Lam (2005) finds that by developing closer institutional and personal links with university researchers, firms and universities develop an internal labour market between themselves, leading to the emergence of a hybrid scientific community across industry and the academia.

Thus, collaboration with universities and PROs is found to be more attractive for firms that rely heavily on external scientific sources, perform R&D at the technological frontier and aim at developing radical innovations for which lack of market information is a barrier (Miotti and Sachwald, 2003). It might as well reflect a form of getting public financing for their internal research agenda (Tether, 2002;

Lam, 2005; Balcony and Laboranti, 2006). Fritsch and Lukas (2001, p.309) find that maintaining one R&D cooperation with universities or research institutes necessitates additional effort, but maintaining a high number of collaborations might enhance substitution and specialization of firms' own research activities.

In particular, from the 1990s, firms seem to have been developing flexible organisational structures to facilitate university knowledge development and transfer (Lam, 2005). The boundaries between university and industry are increasingly loose and it is increasingly difficult to distinguish the roles and careers of researchers of “private” industrial and academic researchers (Lam, 2005). Within the firm, researchers are “research gatekeepers” who connect
firms’ R&D projects to stateofthe art knowledge inputs from the outside research communities. Externally, they protect the firms’ proprietary knowledge resources and investment in collaborative projects, while at the same time, engaging in open knowledge exchange with their external colleagues in order to explore and identify new scientific advances (Lam, 2005, p. 264).

The benefits for firms from collaboration with university include access to new knowledge and the development and maintenance of an ongoing relationship with university as well as to make progress toward the development of new products and processes (Lee, 2000; Monjon and Waelboreck, 2003; Belderbos et al., 2004b). In particular, the larger the number of R&D scientists and engineers a firm has, the less likely the firm is to acknowledge the university contribution to the development of new products and processes (Lee 2000). Moreover, Lee (2000) shows that according to the industry technological managers, collaboration with university only moderately affected publication of patents and the development of solutions for specific problems. Instead, it did not support the improvement of the product quality or the reorientation of the research agendas of firms.

For universities instead, cooperation with firms might be an opportunity not only of exchange knowledge, but also to get funding and to access production technologies and to get prototype manufactured (Balconi and Centuori, 2004; Balconi and Laboranti, 2006). Indeed, Lee (2000) shows that university researchers engage in research collaboration with firms mainly to advance and complement their own research agenda, rather than for entrepreneurship, which seems to be the least of the faculty concerns. In particular, university researchers aim to secure funds for graduates students and lab equipment, to gain insights into their research, to test the practical application of their theory and research, and to get additional funds for their own research. The reasons for collaboration as well as the length of the project are strongly positively correlated with benefits subsequently realized by university researchers (Lee, 2000).

Hence, as Lam (2005) and Lee (2000) argue collaboration between industry and university is a type of market in which academic researchers and firms bring their own research agendas and for which they are willing to commit time, energy and resources. In this market, each part recognises the objectives and agendas of the other part even that most of times they are not formalised. Lee (2000) shows that the reasons identified by industry and those declared by the university as being the goal of firms for engaging in collaboration match very well. As each part allows the

other to achieve its objective, both parts tend to be committed to maintain their level of collaboration (Lam, 2005).

This paper aims at illustrating the universityindustry collaboration market in Brazil. In particular, the motivations for collaboration, the forms in which universities organise and manage collaboration with industry as well as the industrial and academic benefits from collaboration.

3. Methodology and Data

This paper aims at exploring the motivations and impact of universityindustry collaboration in Brazil as well as the way in which university effectively manage and organise this collaboration. In particular, the objective is to analyse whether and how universities need to engage in extra efforts to collaborate with industry as well as to benefit from this collaboration.

To address these issues, we will proceed in two steps.

First, using aggregated data from the PINTEC survey in 2003, which refers to the innovative process of firms from 2001 to 2003, we try to broadly illustrate the pattern of collaborative arrangements to innovate and in particular with university in Brazil. PINTEC is a national innovation survey, which is very similar to the European CIS survey. It collects data on the type of innovation developed by firms, in particular product and process. Moreover, it collects data on the importance of different partners in the process of innovation development and on the object of collaboration, in particular research and development, technical assistance, industrial design, product testing and others. Furthermore, it also collects information on whether the firm received public financing for innovation and for collaboration. Making use of this aggregated information and using some descriptive statistic tools, we analyse how the propensity to engage in collaborative arrangements to innovate, and especially with university differs across industrial activities, firms size and type of innovation. Moreover, we analyse the object of university collaboration as well as the penetration of public support to innovation and in particular to R&D collaboration in different industries and in firms with different size.

Second, using data collected through facetoface interviews with the coordinator of research groups at universities or in PROs, we aim at exploring the reasons for collaboration as well as the required efforts of organisation and management from university to collaborate as well as to benefit from collaboration with industry. In particular, we will focus on research groups in Mathematics and Physics, which have been found to be among the disciplines most important for industrial researchers (Bodas Freitas and Bekkers, 2007). The facetoface interviews aimed at collecting information on the objectives of collaboration with firms, the organisational and management characteristics of these collaborative projects, the efforts put on training on industrial research as well as on the results of the collaborative projects (Annex I).

On the strength of this data, we will analyse the main objectives of collaborative projects with industry undertaken by the nine research groups as well as the main

motivations of research groups to collaborate with industry. Focusing then on one specific model collaborative project in each research group, we explore the most common forms of setting up and management a collaborative project with industry as well as the principal outcomes of these universityindustry collaborative projects.

4. UniversityIndustry Collaboration in Brazil

In this section, we analyse the current universityindustry collaboration market in Brazil. First, we explore at aggregated level how the use of this innovation development strategy is differently used across innovative firms with different size, industrial activities and which engaged in different types of innovation. Second, we analyse the technological, organisational and managerial characteristics of universityindustry collaboration as well as their outcomes for universities and firms, for a sample of research groups at universities and at PROs.

4.1 UniversityIndustry Collaboration: broad aspects

From 2000 to 2003, one third (33%) of manufacturing firms engaged in product or process innovation, in particular 20% developed a product, 27% a process and 14% developed both a product and a process innovation (PINTEC, 2003).

We will now analyse the distribution of cooperative arrangements to innovate, especially with university, across industrial activities and firm size. Table 1 and Table 2 show, respectively across industrial activities and size of firms, the share of innovative firms that cooperated for the development of product and process innovations, the importance of university as innovation partner and the share of innovative firms that benefit from public innovation support, in particular for collaborative research.

Table 1. Collaboration for innovation development across industrial activities

Activities	Total Number of innovative firms	Innovation developed in cooperation with other firms or organisations		Collaboration with university share of firms that collaborate		share of total firms which received public innovation financial support	share of firms that received public financing for R&D collaboration
		Product	Process	High importance	Low or no importance		
Total	28036	3%	1%	18%	70%	19%	1%
Indústriasextrativas	415	0%	1%	45%	26%	18%	0%
Indústriasdetransformação	27621	3%	2%	18%	71%	19%	1%
Fabricação de produtos alimentícios e bebidas	3 563	6%	4%	24%	68%	21%	1%
Fabricação de produtos alimentícios	3 321	5%	2%	25%	68%	22%	1%
Fabricação de bebidas	242	17%	25%	0%	70%	16%	0%

Fabricação de produtos do fumo	13	0%	17%	0%	100%	25%	0%
Fabricação de produtos têxteis	1 111	2%	1%	5%	85%	14%	0%
Confecção de artigos do vestuário e acessórios	3 782	0%	0%	0%	98%	18%	0%
Preparação de couros e fabricação de artefatos de couro, artigos de viagem e calçados	1 143	5%	1%	0%	97%	11%	0%
Fabricação de produtos de madeira	1 609	1%	0%	15%	85%	14%	2%
Fabricação de celulose, papel e produtos de papel	490	2%	3%	21%	71%	22%	1%
Fabricação de celulose e outras pastas	8	22%	33%	67%	0%	33%	0%
Fabricação de papel, embalagens e artefatos de papel	482	2%	2%	15%	80%	22%	1%
Edição, impressão e reprodução de gravações	1 080	1%	0%	0%	88%	25%	4%
Fabricação de coque, refino de petróleo, elaboração de combustíveis nucleares e produção de álcool	64	8%	0%	26%	48%	14%	3%
Fabricação de coque, álcool e elaboração de combustíveis nucleares	39	18%	0%	0%	100%	21%	2%
Refino de petróleo	24	0%	0%	50%	0%	4%	4%
Fabricação de produtos químicos	1 529	6%	2%	19%	55%	14%	1%
Fabricação de produtos químicos	1 216	5%	2%	19%	48%	13%	1%
Fabricação de produtos farmacêuticos	313	6%	3%	17%	71%	16%	2%
Fabricação de artigos de borracha e plástico	1 828	3%	1%	10%	85%	22%	2%
Fabricação de produtos de minerais nãometálicos	1 331	3%	1%	14%	62%	11%	1%
Metalurgia básica	473	10%	1%	46%	43%	12%	5%
Produtos siderúrgicos	141	30%	4%	45%	35%	28%	15%
Metalurgia de metais nãoferrosos e fundição	332	2%	0%	47%	53%	6%	1%
Fabricação de produtos de metal	2 453	1%	3%	8%	91%	18%	0%
Fabricação de máquinas e equipamentos	2 354	1%	1%	10%	80%	16%	0%
Fabricação de máquinas para escritório e equipamentos de informática	143	1%	2%	38%	43%	46%	7%
Fabricação de máquinas, aparelhos e materiais elétricos	699	2%	1%	30%	60%	29%	4%
Fabricação de material eletrônico e de aparelhos e equipamentos de comunicações	348	6%	4%	44%	40%	24%	3%
Fabricação de material eletrônico básico	190	0%	2%	22%	25%	23%	2%
Fabricação de aparelhos e equipamentos de comunicações	158	11%	8%	48%	43%	25%	4%
Fabricação de equipamentos de instrumentação médicohospitalares, instrumentos de precisão e ópticos, equipamentos para automação industrial, cronômetros e relógios	384	2%	1%	41%	54%	16%	0%
Fabricação e montagem de veículos automotores, reboques e carrocerias	772	8%	4%	14%	64%	22%	2%

Fabricação de automóveis, caminhonetas e utilitários, caminhões e ônibus	23	38%	38%	13%	56%	49%	4%
Fabricação de cabines, carrocerias, reboques e recondicionamento de motores	292	6%	7%	17%	83%	16%	1%
Fabricação de peças e acessórios para veículos	458	6%	2%	15%	64%	25%	2%
Fabricação de outros equipamentos de transporte	145	6%	4%	12%	63%	23%	11%
Fabricação de móveis e indústrias diversas	2 264	1%	0%	6%	91%	24%	3%
Fabricação de artigos do mobiliário	1 622	1%	0%	0%	100%	23%	4%
Fabricação de produtos diversos	643	1%	1%	33%	50%	25%	0%
Reciclagem	43	0%	0%	0%	0%	0%	0%

Source: PINTEC 2003

On average, 3 per cent of product innovators innovated in cooperation with other firms or organisations, while 90% of firms develop them on their own and 5% adopted new products developed by other firms. Cooperation to develop new products is particular relevant for firms in automobile industry, metallurgy, electronic equipment, followed by firms in food (in particular beverages), chemical and pharmaceutical and other transport equipment activities. When looking instead at process innovations, we find that 2% of cases process innovation resulted from collaboration with other firms and organisations, while 6% of processes resulted only from the firms internal development efforts and 91 % of firms adopted processes developed by other firms. Cooperation for process innovation is especially important for automobile industry, beverages, followed by electronic equipment, other transport equipment and metallurgy. In particular, collaboration is mainly an innovative strategy of large firms with more than 500 employees, especially collaboration with universities or PROs.

The share of total manufacturing innovative firms that find university collaboration particularly important is higher for pulp and paper followed by electronic equipment, automobile, metallurgy, machinery and equipment. More than one third of cooperative firms (34%) use university as innovation partner for research and development activities as well as for product testing, while only 18% of cooperative firms collaborate with university for other activities such as technical assistance, industrial design, and others.

Table 2. Collaboration for innovation development across firm size

Activities	Total number of firms	Innovation developed in cooperation with other firms or organisations		Collaboration with university - share of firms that collaborate	share of total firms which received public innovation financial support	share of firms that received public financing for R&D collaboration		
		Product	Process				High importance	Low or no importance

Total	28036	3%	1%	1%	3%	19%	1%
De 10 a 29	16 776	2%	6%	0%	2%	17%	1%
De 30 a 49	4 118	1%	3%	0%	1%	20%	1%
De 50 a 99	3 200	2%	4%	0%	1%	18%	1%
De 100 a 249	2 140	2%	5%	1%	2%	20%	1%
De 250 a 499	813	4%	6%	2%	5%	23%	2%
Com 500 e mais	989	21%	26%	9%	24%	34%	6%

Source: PINTEC 2003

Finally, looking at the use of public funds for collaboration with universities and public research organisations, we find that the share of firms that benefit from public support is higher in metallurgy and in other transport equipment, followed by printing, machinery and equipment, automobile, coke, and other manufacturing.

Overall, this descriptive statistics suggest that Brazilian manufacturing firms are more likely to adopt external developed processes than products. Moreover, collaboration with other firms or organisations for the development of new products is slightly higher than for the development of new processes. As in developed countries, collaboration for innovating, especially with universities, seems to be a large firm strategy. Surprisingly, it is the fact that in Brazil scaleintensive sectors such as pulp and paper industry and metallurgy present a higher penetration of the practice to collaborate to innovate, also with universities. These sectors are followed by the most common sectors that collaborated with universities, electronic equipment automobile industry, chemicals, and machinery and equipment. To a certain extent, this evidence might also be related to the fact that PINTEC addresses mainly large firms; consequently leaving out many small hightechnology firms especially in sciencebased industries.

Hence, to understand how policymakers can foster universityindustry collaboration in hightechnology industries, we will now focus on indepth data from the collaborative activity of some research groups, which also perform research in biotechnology, nanotechnology, renewable energies, and information and communication technologies.

4.2 Casestudies: motivation, objective and results from universityindustry collaboration

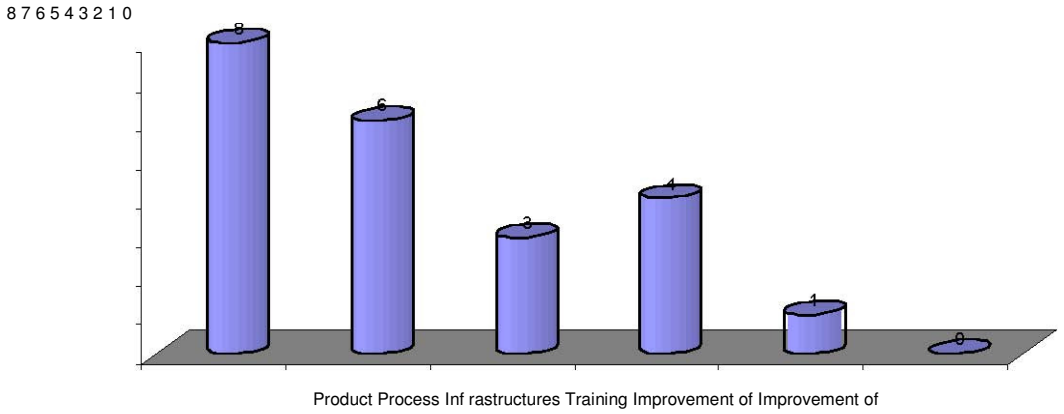
This section examines the results from interviews with coordinators of nine research groups at universities and at PROs, six from Physics and three from Mathematics. All, but one research group, have been collaborating with industry. The six Physics groups had undertaken collaborative projects in the areas of information technologies, biotechnology, nanotechnology and renewable energy.

Instead, two of the three Mathematics groups are undertaking research[1]

mainly related to extraction of petroleum. Still, these nine research groups interact with firms in several industries in particular chemical, petroleum, telecommunication, electronics, software, pharmaceuticals and healthcare, and aerospace.

Graph 1 shows the ranking of the most often objectives and focus of collaboration with industry in the nine analysed research centres. Results suggest that collaboration with industry tends to be set to support the development of new products and processes. Training of firms' employees and industrial use of infrastructures at the university are also often the focus of universityindustry collaboration. Instead, improvement of existing products and processes is not a common objective of the universityindustry collaboration.

Graph 1. Objectives of the universityindustry collaboration for the nine interviewed research groups



[1] In particular, the research group with the largest number of collaboration is one of the Mathematics group, having ten ongoing contracts with firms related to extraction of petroleum.

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versities and at PROs, to collaborate with indu

stry, we find that the development and transfer

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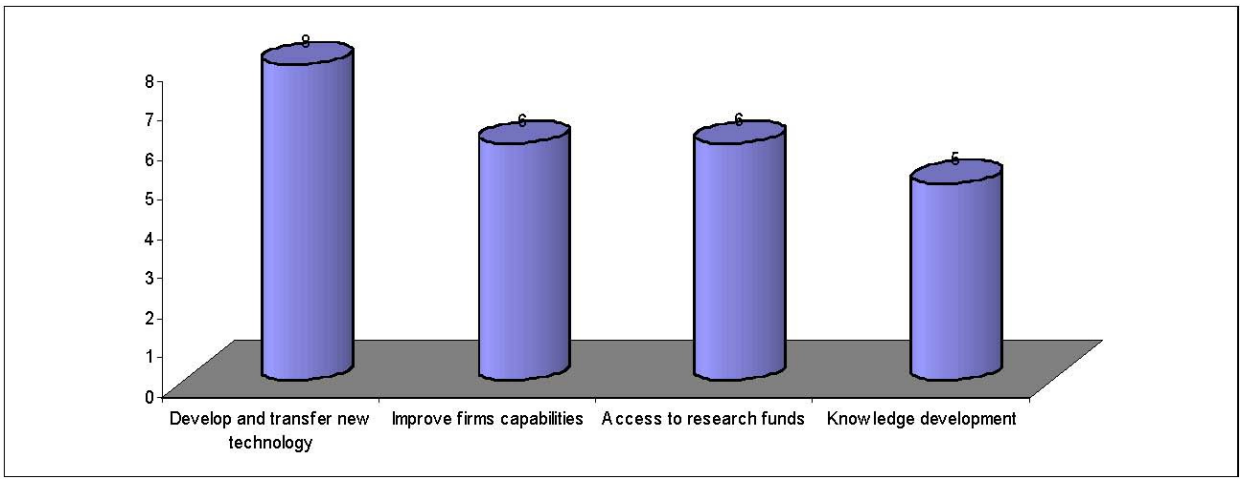
Charter 2. Motivation of the research groups to engage in collaboration with industry



In five research groups, the management of collaborative projects is the responsibility of involved academic researchers. In the other four research groups, management of collaborative projects is a shared responsibility of both the involved researchers as well as an industrial executive. Research groups may need to have formal processes for managing contracts and

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follow the exigencies of funding institutions (government or firms). Moreover, despite having assistance staff, many research groups get help from the university services or the university's foundation to deal with finance, intellectual property rights and contractual procedures.

Table 3 reports the number of research groups that identified each of the following factors as barriers or as facilitators of collaboration with industry.

Table 3. Barriers and Facilitators of universityindustry collaboration

	Facilitators	Barriers
Proximity	6	1
Uncertainty	0	5
Bureaucracy	0	8
Long projects	2	6
Ownership of patents and project's results	4	3
Tax incentives	5	0

Results suggest that proximity, tax incentives and ownership of patents and of project results are seem as facilitators of the success of collaborative projects. High technical uncertainty, bureaucracies imposed by the involved organisations and the longtime frame of collaborative projects tend to be seen as barriers to the completion and success of collaborative research.

Research groups performing research with Petrobras, the Brazilian petroleum corporation, need to follow the procedures set by the firm: submit a proposal; once approved, organize documents and sign the contract; manage the research according the timetable, including the steps, specified in the approved project.

In particular, most research groups say that measures to decrease bureaucracy at the university and to improve institutional support for managing intellectual property rights and other general aspects for managing collaborative projects could permit to expand their actual portfolio of cooperation with industry. Since researchers would need to spend less time in managing and in dealing with bureaucracies and consequently more time to do research.

Additionally, we asked the coordinator of research groups to choose one specific collaborative research project and to characterise its design and management arrangements as well as its main results. Informal contacts via graduate and post-graduate students are unanimously identified as essential for doing the contact at the university or at the firm. Moreover, five different forms of setting up an universityindustry collaborative project were identified:

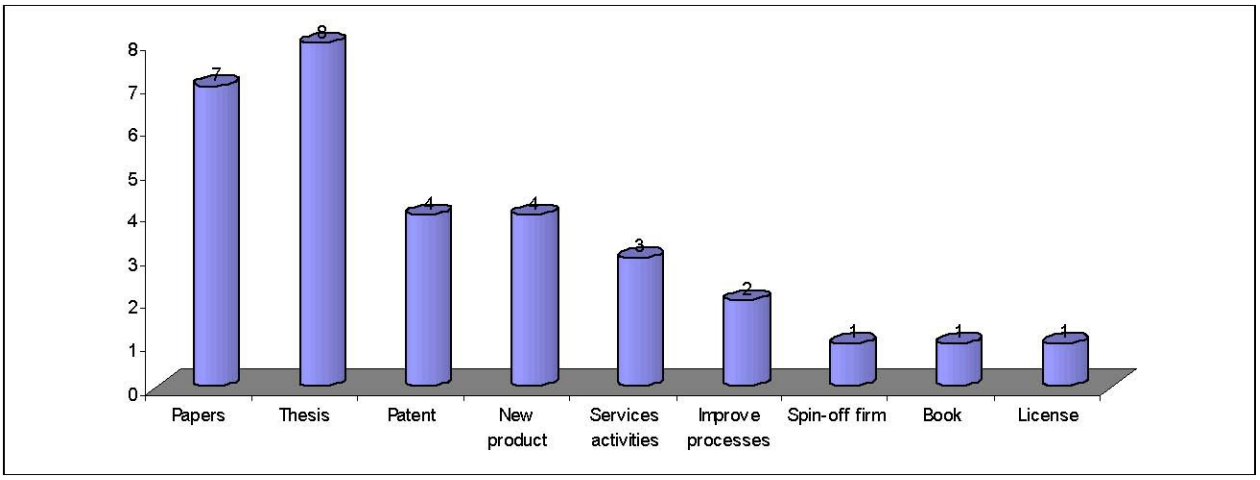
> In the process of product development, the firm contacted the research group demanding help to solve a problem.
>
> The research group identified a possibility of supporting firms to develop new or to improve existing processes (also the market position of the firm) and contacted the firm.
>
> The Brazilian government launched a call for funding collaborative projects and the research group entered in contact with the firm, or viceversa, and submitted a project.
>
> Researchers have a personal contact with employees of the firm, and informally they were undertaking collaborative research.
>
> A postdoc researcher is collaborating with a firm that is interested in using and selling the results of his/hers research, in particular supporting the transfer of the technology.

In eight out of the nine cases, academic researchers undertake some research activities inside the firm mainly for using specific machinery and equipments.

Graph 3 shows the identified results from the universityindustry collaborative projects in the nine research groups. Results suggest that papers and post-graduation thesis are the most often referred results of collaborative research.

Additionally, patents and new products to the market are quite often outcomes from collaborative research projects. Instead, books, licensing of patents, spin off creation and to a less extent improved processes seem to be the least common results from universityindustry collaborative projects.

Graph 3. Results from the UniversityIndustry Collaboration



Finally, we also collected information on the efforts put by these research groups on providing specific training for industry and on supporting the upgrade of the skills of industrial employees. Six of the nine analysed research groups identified three different forms in which their students are trained specifically to undertake industrial research and in which they support the upgrade of the current capabilities of industrial employees:

The professional master degree in which students attend the normal courses, but for
their final dissertation they must develop a solution to a problem identified by the firm;
consequently, students work in collaboration with the firm for solving the problem.
Specific courses within the normal master degree designed to make students focus on a
specific problem of a firm and develop an appropriate solution for the firm.
Tailored qualification course for a firm designed to give to the firm's employees further knowledge on specific technologies and on problemsolving.

Overall, in Physics and Mathematics research groups, collaboration with industry tends to be set to develop new products and processes, and to a lesser extent to provide training to firms' employees or to allow industrial use of university's infrastructures. Moreover, the motivations of academic researchers to collaborate with industry are mainly to develop and transfer a new technology and to support national firms to improve their innovative capabilities, follow by the possibility to

access research funds and to develop new knowledge. Hence, Brazilian researchers seem to have a quite entrepreneurial attitude towards collaborative research.

Looking specifically to a collaborative model project in each research group, we find that most of collaborative research is initiated by firms, which identify problems during their innovative activities. Still, the initiative of university researchers is found to be the second most common way of setting collaboration with industry collaborative projects if university researchers identify and propose to the firm a specific project to improve its process efficiency or its market position. Other factors such as public calls for collaborative research funds and postgraduate research seem as well to be important to set a collaborative project. Informal contacts seem to be essential in all these forms of setting up collaborative research projects in order to facilitate communication and identification of the main industrial and academic players. Papers and postgraduation thesis, followed by patents and new products to the market are the most often referred results of collaborative research. Finally, to improve and expand existing portfolio of collaborative projects, research groups suggest measures that tackle bureaucracy at the university and improve institutional support for managing intellectual property rights and other general aspects related to contractual and financial procedures of collaborative projects.

5. Conclusions

This paper has aimed at exploring the characteristics of universityindustry collaborations in Brazil to better identify how universityindustry collaboration could be improved and innovation development in hightechnology industries fostered through universityindustry collaborations. It has done so by analysing macro aggregate data on the process of innovation development collected by PINTEC as well as by exploring indepth data from nine research groups in Mathematics and Physics, at universities and at PROs on collaboration with industry.

This paper has shown that Brazilian firms engage relatively more in collaborative arrangements for the development of new products than for the development of new processes. Contrary to developed countries in which collaboration with industry is found to be most used in scienceintensive sectors (Tether, 2002; Belderbos et al., 2004), in Brazil, universityindustry collaboration seems more likely among scaleintensive sectors such as pulp and paper, metallurgy and food. To a certain extent, this result might as well reflect the stratified sampling of PINTEC (PINTEC, 2003)

Additionally, this paper has shown that collaboration with industry is mostly set to support the development of new products and processes, and to a lesser extent to support training of firms' employees and industrial use of university's infrastructures. Moreover, academic researchers collaborate with industry mostly to develop and transfer a new technology as well as to support national firms to improve their innovative capabilities. Access research funds and possibility to develop new knowledge are motivations that are slightly lower ranked than those

more entrepreneurial ones. Results concerning the main objectives of the collaborative projects seem very compatible with the existing literature on universityindustry collaboration in developed countries (Hall et al., 2000; Lee, 2000; Balconi and Centuori, 2004; Lam, 2005; Balcony and Laboranti, 2006). Instead, the motivations of academic researchers in Brazil seem to denote wider entrepreneurial objectives than those observed in developed countries, where collaboration with industry is mainly a form to maintain research funds, to complement the group research agenda, and to undertake applied research to get new insights for their research (Lee, 2000; Lam, 2005; Balcony and Laboranti, 2006). Further research should be designed to examine more indepth this hypothesis as well as its motivations and consequences for knowledge and technology development within universities and firms.

Furthermore, analysing in depth a collaborative model project in each research group, we find that collaborative projects tend to be the initiated by firms or by academic researchers, who came out with a proposal for improving the processes or the market position of the firm. Still, public calls for collaborative research funds and postgraduate research seem also important mechanisms for setting up a collaborative research project. Finally, papers and postgraduation thesis followed by patents and new products to the market are the most often referred results of collaborative research.

Overall, these results suggest that to support the innovative activities of firms through universityindustry collaboration, policymakers need to keep in mind that collaborative research depends on the fact that firms feel the need or expect a benefit from collaborating with university. Hence, diffusion of information of successful cases of knowledge transfer from universities to firms as well as support the development of informal contacts through participation ion conferences and especially through the encouragement of graduate and postgraduate thesis at the industry, are or particular importance to support innovative activities of firms. Moreover, as seen, public sponsoring of collaborative projects as well as post-graduate research might as well be important to encourage universityindustry collaboration. Additionally, research groups seem to demand university policies towards the creation of university service that support them to deal with intellectual property rights and other general management aspects of collaborative projects. Hence, to a certain extent the development of a kind of university technology transfer office, which is a wide diffused practice among universities in developed countries, but with specific customised tasks and market might support innovation development and transfer in Brazil.

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Annex I. Interview topics:

A. Research group identification and interviewee contacts
B. Main focus and trajectory regarding collaboration with firms: brief history of the research group; three main research areas, number of researchers and assistants by area, number of papers, thesis, patents, licensing of technology, three main focus of research collaboration (product development, process development, improvement, utilization of lab facilities – technical services, training of human resources, other), number of contracts with firms by research area (formal and informal, finished or ongoing, and by area: nanotechnology, renewable energy, ICTs, biotechnology, other),
C. Characteristics and impact of the research collaborative project identified by the research leader: budget, duration, sources of funding, research aim (new product development, new process, improvement in product and/or process, other.), why the cooperation happened (research group contact the firm, the firm contact the research group, firm's employees having graduation at the research group, other), the research utilizes any machinery at the university or at the firm, results of the project (papers, thesis, patent, new product, new process, technological license, new firm, other), if there was a continuation of the partnership after the cooperation contract ended,
D. Aspects related to the management of the collaboration: responsible by the research management (coordinator of the research group, firm, other...), if there is a formal management, operational aspects necessary to the management (support to the management (staff support), mechanisms for managing communication, legal supervision (lawyer or solicitor help, communication of the research by the university or research centre, project accountancy, elaboration of contracts, managing financial aspects, mechanisms for buying necessary machinery, equipments or others, support to contract services, specify other), identification of aspects that easier of worsen the project management (geographical location of the research group, uncertainty of research results – too risky, institution bureaucracy, duration of the project: too long, ownership of research results, existent tax incentives for investing in research cooperation, institution incentives

for research cooperation, government funding to support research cooperation, communication with the firm, University or research centre structure for supporting research cooperation, research duration defined by the firm, what the research group values most in the cooperation (development of new technology, new knowledge, to help the innovative capability of the firm, specify other), opinion about what could be improved,

E. Activities related to the formation of human resources for technology transfer and/or attend the firm's needs for knowledge update (if there is any ongoing program, explain about the main characteristics, number of people that completed, and results.