What Drives the Formation of Technological Cooperation Between University and Industry in Less-Developed Innovation Systems? Evidence From Brazil*

Ana Luiza L. de Araújo Burcharth
Centre for Organisational Renewal and Evolution (CORE)
Aarhus School of Business, University of Aarhus

Recebido: 02/09/2008 Versão Revisada(entregue): 03/03/2009 Aprovado: 01/07/2009

ABSTRACT

Interorganisational patterns of collaboration have long been recognised in the literature for their potential to promote learning and innovative capabilities, in particular those encompassing university and industry interactions. Yet they are scarcely found in underdeveloped Innovation Systems such as the Brazilian one and little is known about why or how they are established. Drawing upon a comparative case study, this paper investigates in which context technological cooperation between university and industry emerges in Brazil. The findings indicate that the formation of technological cooperation is a co-evolutionary process, which emergences from the practice of knowledge sharing with external partners, as well from the connecting effort of 'linked scientists'.

KEYWORDS | University-Industry Interactions; Innovation Systems; Institutions; Technological Cooperation.

JEL-Codes | O30; O54

* The author thanks the valuable comments and suggestions from Bjorn Johnson, Eduardo Albuquerque and anonymous referees.

O que conduz a formação de cooperação tecnológica entre universidade e indústria em sistemas de inovação menos desenvolvidos? Evidências do Brasil

RESUMO

Diversas formas de colaboração interorganizacional têm sido reconhecidas na literatura por seu potencial em promover aprendizagem e capacidades inovadoras, em especial aquelas envolvendo interações entre universidade e empresa. No entanto, elas são relativamente escassas em Sistemas de Inovação pouco desenvolvidos, como o brasileiro, e pouco se sabe sobre o porquê ou como estão estabelecidas. Com base em um estudo de caso comparativo, este trabalho investiga o contexto em que a cooperação tecnológica entre universidade e indústria surge no Brasil. Os resultados indicam que a formação da cooperação tecnológica é um processo co-evolutivo, que emerge por meio de práticas de compartilhamento de conhecimento com parceiros externos, bem como pelo esforço de articulação de cientistas em rede.

PALAVRAS-CHAVE | Interação Universidade-Indústria; Sistemas de Inovação; Instituições; Cooperação Tecnológica.

CÓDIGOS JEL | O30; O54

1. Introdução

Interorganisational forms of collaboration have long been recognized for their potential to promote learning and innovative capabilities (LUNDVALL, 1992; NELSON, 1993; ETZKOWITZ; DE MELLO; ALMEIDA, 2005). Cooperation is a crucial type of synergy throughout the innovative process, for it provides to partners access to differentiated competencies, markets, shared resources; as well as reductions in time, cost and risk otherwise unavailable (FREEMAN, 1991; POWELL; DOPUT; SMITH-DOERR, 1996). In spite of these acknowledged advantages, studies of Innovation Systems (IS) (at the national, regional or sectoral level) and of the Triple Helix model in less-developed countries recurrently point to the lack of interaction

among the actors (AROCENA; SUTZ, 2000; BERNARDES; ALBUQUERQUE, 2003; ETZKOWITZ; DE MELLO, 2003; LASTRES; CASSIOLATO; ARROIO, 2005; MYTELKA, 2006). There seem to be missing linkages across organisations, as well as a limited translation of academic research into commercial or technological applications in countries like Brazil (MENEGHEL; MELLO; GOMES, 2003; DAGNINO, 2004; RAPINI et al., 2009). As a result, previous investigations have suggested that interactions between university and industry (U-I) are weak and localised, that is, while some firms indeed benefit from their contacts with universities and public labs, for the most part there is little fruitful interaction – a finding that seems to hold among developing countries of Latin America, Africa and Asia (ETZKOWITZ; DE MELLO, 2003; ETZKOWITZ; DE MELLO; ALMEIDA, 2005; RAPINI, 2005; SCHILLER, 2006).

Although these studies are crucial contributions, they provide little help in explaining why or how U-I collaborations hardly emerge in underdeveloped Innovation Systems, as they mainly rely on a snapshot view of them. This paper contributes to this area of research as it sets to investigate the context in which such collaborations are able to emerge. The aim is to understand what are the drivers behind the formation of technological cooperation between U-I in less-developed IS (such as the Brazilian one). Institutions are the analytical focus elected for addressing this question. The aim is thus to examine the role of institutions in determining the environmental context of cooperation (specifically of R&D partnerships[1]). As a point of departure, I make the point that institutions (in the sense of habits and routines) act as a condition for and (probably) as an effect of collaboration. Given that, the following research question is addressed: *what are the institutional drivers leading to the establishment of technological cooperation between U-I in less-developed countries and how do they operate?*

Drawing on a process study of a number of interorganisational collaborations in Brazil, this paper identifies the presence of regular institutional patterns across them. The results thereby uncover the mechanisms by which institutions work and thereby allow the emergence of technological cooperation between U-I in the

1 R&D partnerships designate collaborative arrangements characterised by explicit and systematic linkages among formally independent organisations which involve research and development (R&D) activities at least as part of the cooperative effort. R&D activities refer to methodical processes aiming at expanding the knowledge base of firms, as well as at applying technical knowledge to the creation or improvement of products and processes (not only basic research). Therefore the linkages among partners consist primarily of information and knowledge flows (not merely market transactions), which might or might not be supported by contracts or other formal mechanisms. Thus on-time technology purchases are excluded. Other terms have been used in the literature such as "R&D consortia", "joint R&D agreements" and "networks of technological cooperation" (taken as synonyms).

country. They suggest this is a co-evolutionary (time-dependent) process, which is able to flourish out of the practice of sharing knowledge with external partners, as well out of the connecting effort of 'linked scientists'.

This paper is structured as follows. Besides this introduction, section 2 draws out the theoretical framework for the study. Section 3 outlines the methodological considerations and the cases studies, which are described and analysed comparatively in section 4. The discussion of the research findings is presented in 5, followed by the conclusions of the study in section 6.

2. Theoretical development

There is currently a lively debate about the role of institutions in the development process of nations, coupled with an attempt to define what are the "needed institutions" for economic productivity and progress (NELSON, 2008). This debate is not exactly new, in the sense that it is the result of a long intellectual journey which dates back to Adam Smith and to other exponents like Commons and Veblen. I do not attempt here to reconstruct the history of the concept within economic thinking, but simply to pinpoint that institutions have gained renewed attention since the 1970s, not only as determinants of political and economic performance, but also as an object of inquiry in itself (NORTH, 1990; POWELL; DIMAGGIO, 1991; CAMPBELL; PEDERSEN, 2001; GREGERSEN; JOHNSON; SEGURA, 2004).

Thus the idea that "institutions matter" has been widely accepted within various traditions of research (NORTH, 1990; CAMPBELL, 2004). More specifically in the innovation-related literature, the discussion of institutions has also gained prominence, particularly in writings on innovation systems. The more restricted view of National Systems of Innovation has broadened its focus in order to include elements like labour market institutions, regulatory structures and education systems into the analysis. The recent evaluations of Lundvall et al. (2002) and of Nelson (2008) explicitly acknowledge that the evolutionary framework did not properly consider the complex institutional arrangement that characterizes modern economies during its early elaboration (1970s-1980s). Within this perspective, institutions are understood as "a set of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals and groups" (EDQUIST; JOHNSON, 1997, p. 46). That is, as a social phenomena that clearly differ from concrete entities like any given company (regarded as organisations). As a result, within IS framework, institutions have been attributed a major impact

on learning and innovative capabilities. Since innovation is intrinsically a 'social' and 'interactive learning process' (LUNDVALL, 1992) – that is, the outcome of multi-party interaction carried out inside economic units and between them – it is inevitably affected by institutions (and vice-versa). That is because institutions model the behaviour of agents and regulate the relations between individuals and groups, thereby shaping communication and interaction within the economy (EDQUIST; JOHNSON, 1997).

Despite the recent developments in the IS- literature, there are still many unresolved issues concerning institutions. Nelson (2008) calls attention to three: i) the conceptual vagueness of the term, encompassing various and even contradictory definitions; ii) the unspecified relationship between institutions and economic progress, that is, very little is known about how institutions actually operate; and iii) the unknown process of institutional change. The present paper addresses this research agenda in the sense that it seeks to identify institutions which affect one key element of IS, i.e. the interactivity among actors. In this regard, three elements are proposed which are expected to have a major impact in forging close ties among organisations and thereby in the establishment of cooperative projects of R&D, namely: 'Knowledge Transfer Practices', 'Research Career Structures and Work Norms' and 'Access to Finance'. This choice is justified by the fact that these constructs directly affect the three most important assets throughout the process of technological innovation according to Freeman's (1991) evaluation, namely: knowledge, human capital and money. Although these constructs have been newly developed by this research, they explicitly build upon and advance existing literature (POWELL; DIMAGGIO, 1991; CORIAT; DOSI, 1998; GREGERSEN; JOHNSON; SEGURA, 2004; LAM, 2007; NELSON, 2008). The use of newly developed constructs was a necessary step, as the empirical studies in the field remain relatively scarce, in particular for the context of underdeveloped economies, and a review of this literature indicates that there are multiple ways of assessing the institutional arena (CASPER; KETTLER, 2001; CORIAT; WEINSTEIN, 2002). Moreover, prior research has not addressed explicitly institutions which enable or constrain interorganisational relations and cooperation throughout the innovation process. It is worth noting that the definition of these constructs was purposely kept very broad, given the exploratory nature of the empirical research and the fact that existing research in the topic has mostly addressed the needs and specificities of advanced innovation systems.

2.1. Institutions Supporting Interaction and Cooperation

a) Knowledge Transfer Practices. The possibility of technological cooperation depends greatly on the institutions that provide access to external sources of knowledge. It concerns not only the access to the science base, but also the rules, modes and conventions enabling the movement of knowledge across organisational boundaries. In other words, the processes and mechanisms involved in connecting pools of knowledge and competencies dispersed throughout two or more economic units (CASPER; KETTLER, 2001). Intellectual Property Rights are also important in this regard, along with specific regulations, since they govern how technology can be assigned to third parties. Yet not only are the most formal institutions important. Transfer practices also include the patterns, routines, habits and 'rules of thumb' governing the knowledge flows in interorganisational relations. Intuitively they can be understood as the 'experience with collaboration' or 'the way things are done' when there are partners involved in processes of creation, interchange or application of knowledge (POWELL; GRODAL, 2005). For instance, the way relations are established (informally or endorsed by detailed contracts), how interests are negotiated, the importance assigned to intellectual property rights and the extent to which information is shared when it bears strategic content.

b) Research Career Structures and Work Norms. The way the patterns of research or technological careers support collaboration across organisational boundaries is absolutely fundamental. A key feature is the existence of career structures that span the two sectors (university and industry) and that engage scientists in knowledge production with commercial applications. Such hybrid career paths are so important because they form the so-called 'linked scientists' (LAM, 2007), who engage in the practices of both academia and business, hereby integrating into both frames of mind and work norms. They bear the critical capability of moving back and forth from basic scientific research to practical developments (OWEN-SMITH et al., 2002). As a result, the 'linked scientists' perform the crucial role of reconciling the divergent modes of knowledge development in the academic and industrial environments and, consequently, of creating shared goals and objectives. The alignment of objectives and expectations is a key element for the network formation, since they allow the recognition of common interests and therefore the reasons to collaborate (DOZ; OLK; RING, 2000). According to Lam (2007), the 'linked scientists' are normally

entrepreneurial professors, post-docs or doctorate students, who remain affiliated to the university but engage in some kind of relationship with firms – through joint projects (professors and post-docs) or funding (doctorate students). Yet I see that career-based researchers in companies can also perform this role, since they have been trained in the academia but also participate in the industrial routines. Several elements are associated with the hybrid career experiences – mobility of scientists between academia and industry, employment practices, specific regulation and entrepreneurial culture.

Staff mobility clearly affects collaborative pattern, since they foment the establishment of formal and informal linkages among professionals of a particular field or sector. The building of social ties is critical because they are the ground for the development of connections between organisations. That is, very frequently a partnership is established from the friendship or the personal acquaintance of two individuals. The 'linked-scientists' are normally very strong in networking and therefore are very active in forging interorganisational ties, once they participate in overlapping knowledge networks (LAM, 2007).

Employment practices of firms, hiring/firing routines, together with the specific regulations of the labour market are similarly important. They determine the possibility of transit between job occupations. One key factor concerns the work regime of scientists either in the public or in the private sector, which sets their possibility of working part-time in two or more organisations or of taking temporary licenses to start a business.

Entrepreneurial culture in the academia plays a significant role in sectors not dominated by large firms, such as biotechnology. Spin-offs from universities are crucial for the dynamics of these sectors; therefore they are largely impacted by the motivation of scientists to engage in businesses. In sectors dominated by large corporations, academic entrepreneurship gains a different connotation. It is associated with the activities of researchers that, although retaining full positions at the university, are motivated to form close relationships with the industry. For instance, through consultancy services or collaborative research projects. They are the so-called 'entrepreneurial professors'.

c) Access to Finance. Uncertainty and high costs are intrinsic to projects directed to innovation. Therefore the availability of funding becomes a crucial requisite for the establishment of cooperative R&D projects (O'SULLIVAN, 2005). In Brazil,

traditionally the Government has taken up the role of providing resources for research and technological development, "filling the hole" of the private sector and of the financial market. This is done through direct sponsorships (i.e. Fap.'s, CNPq, and Finep[2]), as well as through fiscal incentives, subsidy programmes and other grants to firms. The high interest rates and the instability of the macro scenario have kept the private sector away from any sort of higher-risk funding. Moreover, the limitations of the stock market do not accommodate strategies for the private financing for firms.

Besides the government strategies for financing research, the way firms internally allocate resources for their innovative activities is a key element as well. The budget for R&D-related activities is a crucial issue, not only in terms of the volume of capital designated, but also in terms of volatility and degree of control. While sufficiency and stability of finance are straightforward arguments, some degree of freedom in the use of funds is a less evident one. It is important to recognise that some slack in the budget may bring up positive impacts, for they leave room for trial and error activities and for the inventiveness of the scientists to flourish. Overall, the availability of high-risk finance directed towards innovative projects greatly impacts the organisation of knowledge production. It cannot be neglected when examining how organisations interact in order to perform R&D activities.

Overall, these are the elements investigated determining the institutional context in which technological cooperation is able to flourish. Table 1 provides an overview of the variables proposed and which have informed the empirical research[3].

2 Fap.'s refer to the funding agencies for scientific and technological research present in each State of the country. CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) is the National Research Council and Finep (Research and Projects Financing), known as the Brazilian Innovation Agency, is a publicly owned company. Both are subordinated to the Ministry of Science and Technology.

3 Nevertheless, this list does not aim to be exhaustive. One can name a set of other pre-requisites for the onset of collaboration, such as the recognition of shared goals and objectives. Such assumptions are not treated separately in the present research, for some are interrelated to the three elements chosen (and for the sake of simplicity). See Doz, Olk and Ring (2000) for a discussion on initial settings for collaboration.

TABLE 1
Proposed Institutional Sets affecting Technological Cooperation in Innovation Systems

Institutional Set	What it is	Elements
Knowledge Transfer Practices	institutions that provide access to external sources of knowledge	- access to science base - rules, modes and conventions enabling the movement of knowledge across organisations -'the way things are done' when there are partners involved in innovation processes - licensing protocols - Intellectual Property Rights and other regulations - trust
Research Career Patterns and Work Norms	institutions that shape the way researchers lead their careers	- hybrid career paths (that span university and industry) - mobility of scientists between academia and industry - "linked scientists", who remain affiliated to the university but engage in relationships with firms - employment practices, hiring/firing routines - labour market regulations and laws - the ability of scientists to relate to peers outside their domain of expertise - entrepreneurial culture in academia
Access to Finance	institutions that provide financial resources	- the way firms leverage/allocate resources for innovation -the way the government supports research - the availability of funds aiming at encouraging university-industry cooperation - national financial market institutions

Source: Author's elaboration

3. Research approach

Following the premises of process research approach[4] (PETTIGREW, 1990; LANGLEY, 1999), a qualitative and comparative case study framework was adopted for the empirical research using semi-structured interviews. A multi-level research was conducted: although the primary focus lied on the meso-level – the R&D partnerships – the aim was to understand how it relates to the institutions at the macro-level and to mechanisms employed at the micro level. All selected cases refer to situations where the partnerships were actually established. Cases in which partners failed to start up the network were not included in the analysis. In addition to the difficulties of selecting and having access to such cases, this

4 For the variables proposed, causal effects a are not defined a priori (so-called "variance approach"). There is no model conceived a priori which could indicate the relationships between the variables and the outcome. Rather the aim was to understand how and why the events develop the way they did, given the exploratory nature of the study. (LANGLEY, 1999).

methodological choice is justified by the premises of the research itself, which is to investigate the role of the institutional environment on arrangements where cooperation did exist.

3.1. Selection of Cases and Data Collection

The selection of cases consisted of two phases: the identification of candidate companies from the MG Survey Database and the exploratory interviews with few candidates.

For the first phase, the MG Survey Database was the starting point. This database gathered information about the innovative activities of 140 R&D-performer industrial firms in the State of Minas Gerais (Brazil)[5] on the same basis as the Yale and Carnegie Mellon Surveys (for further information see RAPINI et al., 2009). From this database, possible candidate companies were selected according to the criteria: i) be part of a sector with a high degree of collaboration; ii) declare that cooperative or joint R&D activities with either other firms or universities were an important – or very important – source of information. Complementary data from the Brazilian National Research Council – the CNPq Directory of Research Groups – was then used to narrow down the selection of firms. This database provided information about the patterns of interaction between research groups and the productive sector. Firms whose collaborations aimed at conducting joint scientific research (with or without immediate practical applications) were selected as opposed to those who had training, licensing agreements and consulting services. As a result, 13 companies were appointed as the best candidates and were contacted for exploratory interviews. They belonged to the following sectors: Mining, Food Industry, Chemicals, Basic Metallurgy, Electrical and Electronic Material, Medical and Precision Instruments. The goal of the exploratory interviews was to check the existence of on-going cooperative R&D partnerships. In total, 13 interviews were carried out in this phase in 12 companies (one refused to participate due to an internal restructuring process) during September-October/2006 through telephone (mostly with R&D managers) and were tape-recorded. They ranged from 20 to 45 minutes. From the brief description of the interviewees, six potential cases were identified. In other words,

5 A South-Eastern state, Minas Gerais has 17.9 million inhabitants and a GDP of US$ 59.6 billion (the 3rd state GDP in Brazil). For Brazilian standards, Minas Gerais could be located at an intermediate level of technological diversification, as it stands in between São Paulo (the leading state) and the remaining ones (Rapini et al., 2009).

I found evidence of the existence of six projects of technological cooperation which fitted the profile I looked for and which were in-progress, meaning that they could be tracked down and studied. Since this research does not focus on a particular sector, companies of the same sector were excluded (there were three from Mining). The criterion used was the number of participating organisations per case, for it was believed that the presence of more participants could greatly enrich the analysis. Thus finally, three out of the six identified cases were selected for detailed investigation, which comprised companies in different sectors: Basic Metallurgy, Chemicals and Mining[6].

3.2. Fieldwork

The selected collaborations consisted of one process development, one product elaboration and one basic research partnership. Since all of them had as the main motivation the creation of new knowledge, they were all considered R&D partnerships. Data was primarily gathered via semi-structured interviews with key stakeholders in each R&D partnership (i.e. project managers, researchers, technicians). The companies that provided the initial access to the research also granted access to their partners (via the 'snowballing approach'). It was hence possible to interview all participating organisations. Access was also sought to project documentation and other sources of information, which were nevertheless denied. For the case studies, 11 interviews were carried out in 8 different organisations between November/2006 and January/2007 (total of 24 interviews). Having collected the interviews, they were transcribed and prepared for analysis, which was made through the software NVivo.

Table 2 provides an outline of the three cases, which are discussed in detail in section 5:

6 If only organizations of the same sector had been chosen, the findings would have become very connected to the context of one sector – a result that wanted to be avoided. Given the fact that there were three cases from the Mining sector, I decided to study the one which had more collaborating partners, as to increase the depth and fruitfulness of the analysis. Given the time limits and resource constraints of the research project, not all six cases could be simultaneously studied.

TABLE 2
Summary of Case Studies

Partnership Purpose	Participating Organisations*	Number Interviews	Interviews per case
1. Research and development of a vaccine against bovine ticks	PharmaVet S.A.	2	4
	University A	2	
2. Development of a refractory compound for the production of steel	Steel Corp S.A.	2	5
	Refractory Materials S.A.	2	
	University B	1	
3. Development of processes for the extraction of Indium	MiningCo S.A.	3	5
	Nuclear Power ResearchCt.	1	
	University C	1	
Total			**14**

Source: Author's elaboration .
Note:* Fictitious names were given to the organisations in order to respect the confidentiality agreements

4. Case studies

This section proceeds as follows. I first present a short description of the cases, anchored in three elements – overview, background and formation process. Afterwards I develop a comparative analysis based on the observation of regular institutional patterns across cases.

4.1. Abbreviated case stories

1. Vaccine against Bovine Ticks
a) Overview: this partnership aimed at developing a vaccine for a parasite (bovine tick) using genetic engineering tools. It was constituted by a biotechnology company which operates in the animal health market and by a public university. It formally started in January 2004 with the expected duration of 5 years. It was mostly funded by the government, as the company's counterpart is relatively very small. The

technology developed within this partnership is innovative in the sense that it deals with a different scientific paradigm – genomics – as compared to the two other vaccines available in the market.

b) Background: PharmaVet has had a solid tradition of cooperation with universities and research centres, which ranges from cooperative basic research to consultancy services. Under its Project Management Department, it has a specific division labelled "University-Industry Relations" to deal with these issues. Besides, it has developed a number of related managerial routines such as the negotiation of clear contracts, the establishment for regular meetings for project accompaniment and the systematic conferences with university researchers for presenting the company's demands. In contrast, the research group at University A had never had a joint R&D project with a private firm. It had only a frustrating experience in 2000, in which it tried to establish an alliance with a multinational but could not come to terms with respect to the contract. Even though this was the very first formal partnership between the partners, they had had a previous contact when one of the university researchers applied for a conference grant with the company. In spite of being temporary, this first contact was helpful in building a good reputation for both parties and therefore was decisive for the establishment of the partnership, as 'university A' researcher recalls: "I have always had a contact with PhamaVet, which is, in my opinion, different from other companies of the sector. It is always looking for things at the universities, meeting us at the conferences (…) For instance, once I organised a panel of Veterinary Immunology within the Brazilian Conference of Immunology and PharmaVet helped to pay it. It conferred a grant to us. And in this way we could bring two international speakers. This was my first concrete interaction with PhamaVet. But it had always been informal"

c) Formation Process: research on the field of bovine ticks had been going on in the university for a long time before this partnership was actually established. It started during the doctorate studies of one of the researchers (1994-1998). The project continued within the university up until 2003, when they had to apply for new grants. But at this time, CNPq eligibility requirements included the participation of a company (it was not mandatory but highly desirable). The university researchers then contacted PharmaVet, presented the project and convinced it to join them. Previous research had already demonstrated that a vaccine was feasible, what could be of great interest for a private business. PharmaVet was elected in

particular because it is a national company (following CNPq requests) and because of its recognised internal capabilities. Although PharmaVet has received many proposals from university research groups, it decided to enter this partnership because it was regarded very promising in terms of the market potential of the application and because of the limited commitment of resources required in terms of finance and manpower. A contract between PharmaVet and the technology transfer office (TTO) from the university was still under negotiation at the time of the interviews (many problems were faced with the TTO, who had been prolonging the process). Nevertheless, there is a verbal agreement between the parties which specifies issues of intellectual property rights, as well as the regularity of meetings, the visits of researchers from PharmaVet to the university, the research schedule and the work division. Furthermore, it is worth emphasizing that the exigencies set by PharmaVet concerning the establishment of the partnership were much easier to meet than those required by the multinational in 2000. This was considered an important facilitator by all interviewees.

2. Refractory Compound for Steel Production

a) Overview: this partnership is formed by a steel producer (Steel Corp S.A.), its supplier of refractory ceramics (Refractory Materials S.A) and a public university. It formally started in June 2006 (expected duration of 16 months) with the purpose of developing a non-castable refractory ceramic used within the blast furnace of the coke plant during the steelmaking process. It can be regarded as non radical (or incremental) innovation, for it constitutes an effort of 'internalisation of technology'. Besides been produced elsewhere (i.e. Japan), it is embedded within the established practices of the industry. In relation to finance, the cost of the project is shared. Each company is responsible for its own expenditures (inputs, wages, etc.). The university professor does not charge for his hours specifically spent in this project, because he receives a fixed amount from each company for the other projects he develops with each firm. There is no government funding.

b) Background: In spite of being the first time the partners establish a formal project which involves all of them; they have developed solid dyadic relationships over time. Steel Corp S.A. has long been a client of Refractory Materials S.A. for refractory ceramics. For this reason they have built joint routines for solving problems on a continuous basis. Such collaborative work provided the basis for the linkages between the companies, which have gradually evolved. According to the

R&D manager, "Steel Corp. is one of our most exigent clients and therefore one of the most important. They continuously assess our efficiency in providing technical solutions to their needs (…) We have a very good partnership with Steel Corp., that is, we have a good transit in there, good technical feedbacks and vice-versa. They have it as well. Thus, although we have not worked in such a formal way as it is now, we have always worked in thigh collaboration in the day-to-day routines, in the solution of simple and complex problems". With regards to University B, it is a young university who has traditionally been directed towards interaction with industry. Moreover, the research group participating in this partnership is recognised worldwide for its expertise in refractory compounds and in cement and concrete research. The leading professor has had experience of interaction with firms for over 17 years. As a matter of fact, both firms have had previous experiences with him. Steel Corp S.A started the collaboration with a training programme in the 1980's, with gradually evolved to cooperative R&D projects. The history with Refractory Materials S.A is more recent, having started in 2001 with the contract of a consultancy service. Students supervised by the leading Professor were also hired to fulfil research positions at the company.

c) Formation Process: This partnership was formed as a result of a direct demand from Steel Corp., who wanted to develop a refractory compound used within the blast furnace throughout the production of steel (during the coke-making process). This compound had been imported from Japan. The demand emerged from the operational division and was then directed to the R&D department. It saw it was important to develop the technical capabilities of a domestic supplier for to two reasons: i) to have a refractory compound adapted to its specificities and needs; ii) to reduce its dependency on external suppliers and on related issues of costs, logistics and import. Having identified this clear demand, Steel Corp. invited the other organisations to join the network. Refractory Materials S.A. decided promptly to join the project because it understood it was as part of its obligations to meet the demands of its clients, in special of an important client such as Steel Corp. It saw, moreover, this project as a "natural development" of the relations they had maintained throughout years, focused on the solution of minor technical problems. For the leading professor at University B, similarly, this project was seen as a part of the overall collaboration frame it maintains with both companies in such a way that it seemed "obvious" to him to assist them in the development of this refractory ceramics. Hence, this R&D partnership is

the outcome of a long-term record of relationship dyads anchored on technical cooperation.

It is structured around a detailed contract signed by all participating organisations. It specifies the budget, the timeline, the objectives, the execution plan and everything else related to the proposal. Moreover, it determines that Steel Corp. has no exclusive agreement. That is, when developed, Refractory Materials can sell the technology to other companies and eventually to competitors. In terms of management, all partners are effectively engaged in the joint-development of the project and there is a clear distribution of tasks: "The work division is done in accordance with the knowledge and the competences of each partner. Refractory Materials will develop the compound itself, plan the industrial experiments and carry them out together with the Professor and with Steel Corp. Besides being responsible for conducting the tests and experiments within its manufacturing plant, Steel Corp. is supposed to provide the needed equipments and the Japanese compound currently used. The researcher of University B will provide technical support to the research, interpret and analyse the results as well as write the final report. In this way all partners contribute". Researcher from Steel Corp. S.A.

3. Indium Processing

a) Overview: the partners are a large corporation from the mining sector, a public research centre (Nuclear Power Research Centre, NPRC henceforth) and a public university, who contributes informally to the project. The partnership aimed at developing processes for the extraction and the production of Indium, a by-product from MiningCo's plant which had been discarded for a long time. Its extraction became very attractive because of the good value the metal had gained in the market (US$ 1 million/ton in 2006) due to its application in plasma screens. The network started in 2005 and, at the time of the interviews, large scale production of Indium was expected to start in January 2008.

b) Background: Before this project was started, MiningCo S.A. had developed dyadic relationships with both NPRC and University C. For this reason it bears a central position in the network. The relationship with NPRC started in the early 1990s. Since then, several projects have been developed in collaboration. For instance, MiningCo facilities for the production of lead silver concentrates had been designed by technicians and researchers from NPRC. It is important to stress that NPRC is particularly focused on the development of technologies applied to the

industry, that is, it has long experience with collaboration. Regarding the university, although MiningCo has always employed students from University C, systematic connections were established more recently. The first contact started with an initiative of the university. The leading professor asked for a compound extracted by MiningCo which would be used in the master's dissertation of one student. His active role cannot be underestimated, as he commented: "What is the strategy we employ for establishing linkages with firms? When we spot something a private firm may possibly be interested in, we firstly develop a student project, either a master's dissertation or a Ph.D. thesis. Then we show to the industry the most promising results so that it can get to know our work. With MiningCo, this was exactly what happened. We obtained a sample of an ore extracted for the dissertation of one of my students. Later, we invited the technology manager for the examination. In this way, he became interested in setting up a formal project with us". Since then (2003), the collaboration evolved in such a way that several research projects were launched in cooperation. The Technology Manager from the company also decided to pursue his master and Ph.D. studies at the university, supervised by the leading professor. MiningCo is today one of the most important and active partners of this research group.

c) Formation Process: research on a route for the extraction of Indium had been carried out by scientists at NPRC for many years. The one who is actually engaged in the partnership investigated the processing of Indium in her doctorate studies (1995-1999), for she perceived an important demand (the ore was exploited in other countries but thrown out as a reject in Brazil). Having identified this research opportunity, the scientist tried to learn the technology in Canada, though without much success. It then became clear that the required competencies had to be developed internally. As a result, the research team from NPRC launched an alliance with a mining company named Greenhills Zinc Mine (fictitious name) between 1998 and 2002. At this time they managed to establish a set of processes which made the extraction of Indium economically feasible. Nevertheless, Greenhills Zinc Mine ended up not implementing it because it was going through a period of financial turbulence. MiningCo got access to the project through the acquisition of Greenhills Zinc Mine in 2003. Yet it was only later that MiningCo decided to further develop it. When a strategy of expanding the portfolio of metals was set at the corporate level, the exploitation of Indium became an attractive business. The high market values were also a key driving force. As a result, the scientist of NPRC was again

reached and the alliance formally started in 2005. She also gave a workshop on solvent extraction techniques at the company, which she regarded as very helpful for levelling knowledge among the partners (clear lexicon differences existed among them) and for getting the company interest in it. For her, joining the initiative of MiningCo was an "easy decision" as she has put it, given her long-lasting will to put the solution into practice. The professor from University C was also invited by MiningCo to contribute informally to the partnership. Because he has a very good relationship with the company's Technology Manager, he provides technical support when needed but without being legitimately in charge of the project or effectively interacting with all partners. For this reason, his decision was also taken very informally, seen as a "expected" development of his close relationship to MiningCo. Furthermore, it is important to stress that the technology is substantially different to that developed for Greenhills Zinc Mine. A different route was actually elaborated.

4.2. Cross-case analysis

The cases presented reveal the complexity and the diversity of the social processes underlying the formation of cooperative arrangements directed towards R&D. Nevertheless, an outline of the general implications can be drawn, for some regular institutional patterns have been observed.

Firstly, with regards to 'Knowledge Transfer Practices', the cross-case examination reveals high heterogeneity of the research groups interviewed in terms of their ability of dealing with property right issues or in establishing effective mechanisms of knowledge transfer. While Universities A and C had limited experience of interacting with private firms, University B and NPRC had a long tradition of cooperative projects and demonstrated to be familiar with "the rules of the game" from the start of the cooperation. Evidence came from the fact that University B had long-term contracts with both partner companies and NPRC had a specific department to deal with collaboration and which appeared to be helpful in arranging the research contracts. As far as the companies studied are concerned, all had practice in utilizing knowledge from external sources, although in different ways. While PharmaVet actively searched for scientific knowledge in the form of basic research, MiningCo., Steel Corp. and Refractory Materials used university knowledge mostly for consultancy and training purposes.

Thus, all organisations investigated in the fieldwork appeared to have developed 'knowledge transfer practices' to different extents[7]. Such practices were crucial not only for the negotiation of the terms of the contract but, more importantly, they allowed partners to establish common frameworks for action as well as common understandings. Previous experiences with collaboration – successful or not – were fundamental, for they provided the ground for the flourishing of the actual R&D partnerships. This was especially evident in the Vaccine case, in which the lack of familiarity of the university team (and of its technology transfer office) with such matters was counter-balanced by the know-how and experience of PharmaVet. The company agreed to temporarily work on informal terms before the contract could be prepared and signed (what had not occurred in the earlier negotiations of the university with the multinational). The company also drew on its previous partnerships to structure the collaboration with University A in terms of definition of work schedule, division of tasks and knowledge sharing. Therefore one can see two interconnected dimensions underlying the construct 'knowledge transfer practices'. On the one hand, it is associated with the background of the organisations – their "baggage" from previous interorganisational relations. On the other, it is connected to the relation between the partners themselves, as well as how it has evolved over time (see figure 1). The latter dimension was decisive also to the development of knowledge sharing mechanisms and to the way behaviour is guided and addressed among partners. As stressed by Doz, Olk and Ring (2000: 241), "when there have been prior relationships between participants, some shared expectations are likely to be present from the onset of the collaboration".

It is important to highlight the role that inter-temporal dynamics played with regards to the development of 'knowledge transfer practices'. In all cases investigated, cooperation evolved over time – from sporadic agreements (i.e. on-time consultancy services) to more sophisticated ones. For instance, in the *Refractory Compound* partnership, the two companies started with a typical user-producer interaction (LUNDVALL, 1992) devoted to the solution of minor technical problems. This finding points out the importance of time not only to the development of trust (as stressed by previous studies such as Doz (1996), but also to the development of shared organisational practices and the sense of a community which are vital

7 Even the research group from University A – arguably the one with the least developed 'knowledge transfer practices' – had had a previously unsuccessful experience of collaboration, which served as an important learning experience as highlighted by the interviewees themselves.

components of the knowledge creation processes. 'Learning by doing' and 'learning how to learn' appeared to be key elements in this regard. The cases reveal that there are interrelated learning processes in play in the sense that throughout time organisations learn how to collaborate with others and to create knowledge jointly.

Secondly, in terms of 'Research Career Structures and Work Norms', the present research corroborates Lam's (2007) argument on the need of 'linked scientists'. They played outstanding roles in two of the partnerships – *Refractory Compound* (professor from University B) and *Indium Processing* (professor from University C and Technology Manager from MiningCo). The fact that a 'linked scientist' was less important in the formation process of the partnership Vaccine might be explained by the fact that the project is closer to basic research and mainly conducted in the premises of the university, what lessened the need to integrate knowledge (basic science to technological applications). It came with no surprise the comment of all interviewees on the differences of work environment between academia and industry, remarkably with regards to the work pace, timing and objectives. For this reason, the 'linked scientists' were so important for these two network formation process, as they were able to reconcile such intrinsic divergences, acting towards the integration of the diverse frames of mind. Moreover, the evidence suggests that the 'linked scientists' have well developed 'integrative capabilities'. In the terminology of Owen-Smith et al.(2002), it means that they have proved to be able to move back and forth from basic science to commercial or technological applications – a crucial capability within R&D partnerships which involve both knowledge organisations and private firms. As the citation of University C researchers suggests, he has been able to turn the results of student projects into applicable solutions with interest to private companies.

Other authors have pointed out the importance of such figures. Doz, Olk and Ring (2000), for instance, have called them the "triggering entity". This paper does support the argument of Doz, Olk and Ring (2000), accepting that 'linked scientists' can work as "triggering entities". Bridging organisations, which stand between science and business, have also proved to perform such a role (i.e. NPRC), which can also take the form of technological institutes, knowledge intensive business services, among others. They can actually work in a more systematic way, for they are independent of the personal inclinations of a few scientists.

The interviewees reported that one can still find resistance in the academia towards collaboration with private firms, seen as depreciative or as a kind of deviation from the purposes of science. The classic dilemma of publishing versus

confidentiality agreements with industry was also repeatedly mentioned as an important constraint, for the researchers were evaluated by the different government agencies exclusively according to their number of publications. From this basis, it can be implied that the hybrid career patterns were much more of an exception rather than the rule in Brazil. The presence of 'linked scientists' was said not to be a very common career choice, that is, there are few professors in the academia with an entrepreneurial profile and few researchers in the private sector capable of performing such a role. Hence, the career perceptions and professional values of the scientists interviewed in this study might not be representative of the whole community. When they were asked about their motivation to engage in collaboration, they put altruist motives before commercial gains (i.e. contribute to the technological development of the country). Purely commercial interest seemed to be dissuaded within the scientific community in the country. Yet the obtainment of resources to research projects was one of most common drives for cooperation, together with the enrichment of research agenda and the offer of work opportunities to students.

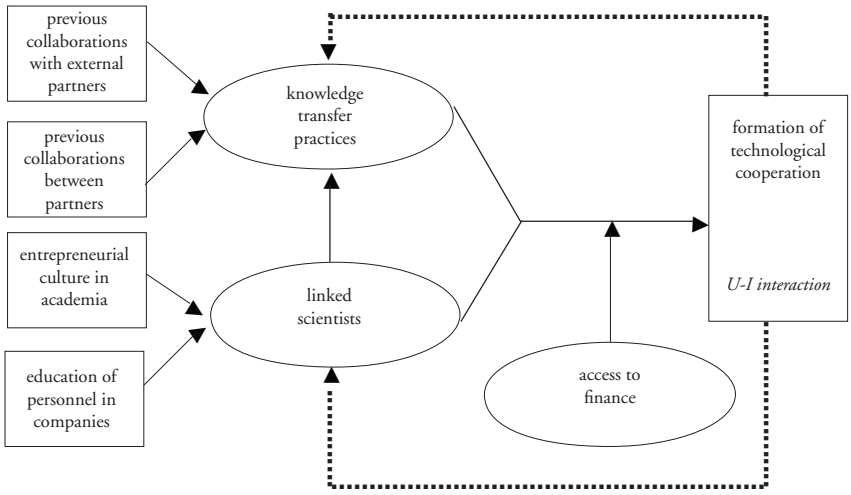
Thirdly, concerning 'Access to Finance', the data suggested that this factor was the driving force in only of the cases, namely the *Vaccine* case. Clearly, the motivation of the university research team to contact the company was to increase the odds of obtaining funds with CNPq. This case thus provides a initial indication of the impact of the recent changes in the government strategy of financing research. Nevertheless, it is worth stressing the finance itself cannot explain the establishment of this cooperation, as exemplified by the unsuccessful experience of the research team with the multinational company. As mentioned earlier, the existence of well developed 'knowledge transfer practices' in PharmaVet was crucial, given the difficulties of establishing a contract between the parties.

For the *Refractory Compound* partnership, access to finance seemed to play no role at all, as partners were ultimately concerned with having access to each other's complementary capabilities. The companies shared the costs of the project, while the university researcher received no extra funds for his participation. Finally, the *Indium Processing* case. While there was no evidence that access to finance was the driving force behind the formation of the partnership itself, it was clearly a factor of importance behind the relationship between partners. This was especially evident in the relation of the professor from University C with MiningCo., for he actively sought external funding from companies for the maintenance of his research group.

5. Research findings

This research has explored the impact of institutions in the formation process of technological cooperation between U-I in Brazil. The study has shown that, under specific conditions, universities and private companies are able to bridge their differences and work jointly for the production of knowledge. The contribution of this paper has been to unpack these conditions and provide evidence of how they operate. The paper has made the point that institutions determine the environmental context in which technological cooperation is able to flourish, acting not only as a pre-condition for, but also as a result of interorganisational collaboration. As portrayed in figure 1, the results suggest that two crucial elements of such context are 'knowledge transfer practices' and the connecting effort of 'linking scientists'.

FIGURE 1
The role of institutions in the formation process of R&D partnerships:
an illustration of main research findings



Source: Author's elaboration.

First of all, the development of systems and procedures for knowledge sharing with external parties has been recognized as absolutely crucial for all the partnerships studied. They provided the means for the collaboration, conditioning the knowledge production process. In the case of the organisations interviewed, they

were determined at the organisational level (by previous experience with external parties and between partners themselves) and also at the individual level (by the "baggage" of linked scientists), as illustrated by the recursive arrow of figure 1. This is because linked scientists brought in their capability to relate to peers outside their domain of expertise and their particular ways of doing so. Second, linked scientists themselves have showed to play a key role for the establishment of technological cooperation, in particular for the *Refractory Compound* and *Indium Processing* cases, where the individual agency was decisive. Two factors influence the endeavour of linked scientists – the entrepreneurial culture in the academia and the training policies of R&D personnel in companies, which are portrayed in figure 1. Third, the findings point to the fact that 'access to finance' works more as a catalyst than as a key constituent of the process. Actually it was a driver in only one of the cases investigated. I argue it functions only if the other elements of the context are in place.

Furthermore, figure 1 depicts feedback arrows which illustrate the fact that the R&D partnership itself impacts the practices of knowledge sharing of the parties involved, as well as the career development of linked scientists. They are illustrated as dotted lines, since this research has not been able to completely capture such effects. Yet it has found evidence of an on-going process of institutional change, which seems to have started in the last 8-10 years. It is likely that the interviewees are the typical people at the vanguard pulling the alterations in behaviour. For instance, it was reported that the ethos in academia had undergone some modifications in the sense that "academic entrepreneurship" has been much more accepted and stimulated (it was said to be much discriminated until very recently). Another evidence of the changes-in-progress came from the fact that the recent government strategies of financing research are driving scientists to set up linkages with the industry as a means of survival. I argue this can be characterised as a co-evolutionary process of change rather than a revolutionary change (in the sense of a drastic departure from the past). That is, as a continuous and incremental process in which institutions develop together with interorganisational collaborations in a dynamic and interconnected fashion.

Yet it is important to stress the limitations of these results with respect to sampling and to the generality of conclusions. Findings drawn from a few case studies (no matter how carefully they have been selected and analysed) obviously deserve caution. The results are not alleged to produce broad generalisations, for they are designed precisely to capture the details or specificities of the process under investigation. As far as generalization of results is concerned, this research makes

claims only about Brazil, even though it is expected that some results would hold elsewhere (i.e. Western European Countries). This important restriction is due to the inherent context-dependent nature of any institutional analysis and to the unique choice of variables, which makes the comparisons with previous literature limited.

6. Conclusions

The present study has examined the issue of how institutions interact with organisational structures and processes to support collaboration in interorganisational contexts, specifically between university and industry. Theory-wise, the main contribution was to suggest intermediate analytical structures which allowed the concept of institution to become workable at the empirical level, thereby unpacking it. From an empirical point of view, the contribution of the paper was to provide a detailed report on the establishment of three R&D partnerships within an underdeveloped Innovation System (in Brazil). The findings point out to the fact that university and industry are able to collaborate when: i) participating organisations have experience with collaborative projects and ii) there is a "linking person" who is able to integrate divergences of work environments.

Furthermore, this research has made an important observation about the presence of inter-temporal dynamics in collaboration. All collaborations examined developed from sporadic relations (such as training and consultancy) to more sophisticated ones characterised by joint creation of knowledge, what indicates that organisations need to learn how to work together and that it takes time to do so. In this way the institutions seemed to be developing together with the R&D partnership in a dynamic and interconnected fashion, constituting a co-evolutionary process of change. Along these lines, the present research brought up evidence supporting the point of view of diversity in work environments, for diversity has shown to stimulate the development of distinct bodies of knowledge which possibly can be integrated in interorganisational contexts through the effort of 'linked scientists'.

All in all, the cases studies provided the opportunity to investigate the phenomena of technological collaboration between U-I behind the statistical figures collected by previous studies – 'a zooming-in' – in the belief that different methodological approaches can enrich and complement each other. In this way it adds to the existing literature on National Systems of Innovation, which has sought to comprehend the links between the macro-institutions at the national level, the different patterns of industrial dynamics and the innovative performance of firms.

References

ALBUQUERQUE, E.; SILVA, L.; RAPINI, M.; SOUZA, S. Interactions between firms and universities in an immature system of innovation: a survey of industrial R&D performers firms in Minas Gerais, Brazil. In: THIRD GLOBELICS CONFERENCE. South Africa, 2005.

AROCENA, R.; SUTZ, J. Looking at National Systems of Innovation from the South. *Industry and Innovatio*n, v. 7, n. 1, p. 55-75, 2000.

BERNARDES, A. T.; ALBUQUERQUE, E. Cross-over, thresholds and interactions between science and technology: lessons from less-developed countries. *Research Policy*, v. 32, p. 865-889, 2003.

CAMPBELL, J. L. *Institutional change and globalization*. Princeton, N.J.: Princeton University Press, 2004.

CAMPBELL, J. L.; PEDERSEN, O. K. (Eds.). *The rise of neoliberalism and institutional analysis*. Princeton, N.J.: Princeton University Pressed, 2001.

CASPER, S.; KETTLER, H. National institutional frameworks and the hybridization of entrepreneurial business models: The German and UK biotechnology sectors. *Industry and Innovation*, v. 8, n. 5, p. 5-30, 2001.

CORIAT, B.; DOSI, G. The institutional embeddedness of economic change: an appraisal of the 'evolutionary' and regulationist' research programmes. In: K. NIELSEN; JOHNSON, B. (Eds.).*Institutions and economic change*: new perspectives on markets, firms and technology. London: Edward Elgar, 1998.

CORIAT, B.; WEINSTEIN, W. Organizations, firms and institutions in the generation of innovation. *Research Policy*, v. 31, p. 273-290, 2002.

DAGNINO, R. A relação universidade-empresa no Brasil e o argumento da hélice tripla. *Convergencia*, v. 11, n. 35, p. 253-291, 2004.

DOZ, Y. The evolution of cooperation in strategic alliances: initial conditions or learning processes? *Strategic Management Journal*, v. 17, n. summer special issue, p. 55-83, 1996.

DOZ, Y.; OLK, P.; RING, P. S. Formation process of R&D consortia: which path to take? Where does it lead? *Strategic Management Journal*, v. 21, p. 239-266. 2000.

EDQUIST, C.; JOHNSON, B. Institutions and organizations in Systems of Innovation. In: EQUIST, C. (Ed.). *Systems of Innovation*. London: Pinter, 1997.

ETZKOWITZ, H.; DE MELLO, J. M. C. The rise of a triple helix culture. *International Journal of Technology Management & Sustainable Development*, v. 2, n. 3, p. 159-172, 2003.

ETZKOWITZ, H.; DE MELLO, J. M. C.; ALMEIDA, M. Towards "meta-innovation" in Brazil: the evolution of the incubator and the emergence of a triple helix. *Research Policy*, v. 34, n. 4, p. 411-424, 2005.

FREEMAN, C. Networks of innovators: a synthesis of research issues. *Research Policy*, v. 20, n. 5, p. 499-514, 1991.

GREGERSEN, B.; JOHNSON, B.; SEGURA, O. Institutions and learning capabilities in a development perspective. In: DRUID SUMMER CONFERENCE 2004. Elsinore, Denmark. June 14-16, 2004.

LAM, A. Knowledge networks and careers: Academic Scientists in Industry-University Links. *Journal of Management Studies*, v. 44, n. 6, p. 993-1.016, 2007.

LANGLEY, A. Strategies for Theorizing from Process Data. *Academy of Management Review*, v. 24, n. 4, p. 691-710, 1999.

LASTRES, H. M. M.; CASSIOLATO, J. E.; ARROIO, A. *Conhecimento, Sistemas de Inovação e Desenvolvimento*. Rio de Janeiro: Editora URFJ Contraponto, 2005.

LUNDVALL, B.-Å. (Ed.). *National Systems of Innovation*: towards a theory of innovation and interactive learning. London: Pintered, 1992.

LUNDVALL, B.-Å.; JOHNSON, B.; ANDERSEN, E.; DALUM, B. National systems of production, innovation and competence building. *Research Policy*, v. 31, p. 213-231, 2002.

MENEGHEL, S.; MELLO, D.; GOMES, E. The university-industry relationship in Brazil: trends and implications for university management. *International Journal of Technology Management & Sustainable Development*, v. 2, n. 3, p. 173-191, 2003.

MYTELKA, L. K. Pathways and policies to (bio)pharmaceutical innovation systems in developing countries. *Industry and Innovation*, v. 13, n. 4, p. 415-435, 2006.

NELSON, R. (Ed.). *National innovation systems*: a comparative analysis. New York: Oxford Univrsity Pressed, 1993.

_____. What enables rapid economic progress? What are the needed institutions? *Research Policy*, v. 37, p. 1-11, 2008.

NORTH, D. *Institutions, institutional change and economic performance*. Cambridge, England: Cambridge University Press, 1990.

O'SULLIVAN, M. Finance and Innovation. In: FANGERBERG, J.; MOWERY, D.; NELSON, R. (Eds.). *The Oxford handbook of innovation*. New York: Oxford University Press, 2005, p. 240-265.

OWEN-SMITH, J.; RICCABONI, M.; PAMMOLI, F.; POWELL, W. A comparison of U.S. and European University-Industry Relations in the Life Sciences. *Management Science*, v. 48, n. 1, p. 24-43, 2002.

PETTIGREW, A. Longitudinal field research on change: theory and practice. *Organization Science*, v. 1, n. 3, p. 267-292, 1990.

POWELL, W. W.; GRODAL, S. Networks of innovators. In: FANGERBERG, J.; MOWERY, D.; NELSON, R. (Eds.). *The Oxford handbook of innovation*. New York: Oxford University Press, 2005, p. 56-85.

POWELL, W. W.; DIMAGGIO, P. J. (Eds.). *The new institutionalism in organizational analysis*. Chicago: University Pressed, 1991.

POWELL, W. W.; DOPUT, K. W.; SMITH-DOERR, L. Interorganisational collaboration and the locus of innovation: networks of learning in biotechnology. *Administrative Science Quarterly*, v. 41, n. 1, p. 116-145, 1996.

RAPINI, M. S. *Interação universidade-empresa no Brasil*: evidências do diretório dos grupos de pesquisa do CNPq. Belo Horizonte: UFMG/Cedeplar, 2005 (Texto para Discussão).

RAPINI, M. S.; CHAVES, C. V.; ALBUQUERQUE, E. M.; SILVA, L. A.; SOUZA, S. G. A. D.; RIGHI, H. M.; CRUZ, W. M. S. D. University-industry interactions in an immature system of innovation: evidence from Minas Gerais, Brazil. *Science and Public Policy*, v. 36, p. 373-386, 2009.

SCHILLER, D. Nascent innovation systems in developing countries: university responses to regional needs in Thailand. *Industry and Innovation*, v. 13, n. 4, p. 481-504, 2006.

ENDEREÇO PARA CORRESPONDÊNCIA:

Ana Luiza L. de Araújo Burcharth - alla@asb.dk
PhD Researcher
Centre for Organisational Renewal and Evolution (CORE)
Aarhus School of Business, University of Aarhus
Haslegaardsvej 10, DK-8210 Aarhus V, Denmark
Tel.: +45 89486704