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How do institutions shape the formation of technological cooperation? Evidence from Brazil

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Abstract

Interorganisational patterns of collaboration have long been recognised in the literature for their potential to promote learning and innovative capabilities. 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 study of a number of interorganisational collaborations, this paper investigates how technological cooperation emerges in Brazil. The focus lies on role of institutions in the formation process of R&D partnerships. Regular institutional patterns across cases are identified, alongside with the mechanisms by which they operate. 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: innovation system, institutions, R&D partnerships, technological cooperation

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1 Introduction

Interorganisational patterns of collaboration have long been recognized in the literature for their potential to promote learning and innovative capabilities (Freeman, 1991; Powell *et al.*, 1996). R&D partnerships, multi-partner networks and strategic alliances are some of the possible arrangements for exploiting external sources of knowledge and competences. Innovation is inescapably embedded in these various forms of interorganisational relationships, given its interactive and context-dependent nature (Lundvall, 1992). 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.

In spite of these acknowledged advantages, studies of Innovation Systems (at the national, regional or sectoral level) in less-developed countries recurrently point to the lack of interaction among the actors (Arocena and Schutz, 2000, Cassiolato and Lastres, 2000, Bernardes and Albuquerque, 2003; Latres, Cassiolato and Arroio, 2005). There seem to be missing linkages across organisations, as well as a limited translation of academic research into commercial or technological applications. These studies typically present a wide set of statistics and figures which make out a very general picture, based on interactive research groups and on industrial patterns of collaboration (Rapini, 2005; Albuquerque *et al*., 2005; Cassiolato, Britto and Vargas, 2005). Although they are crucial contributions, they provide little help in explaining why or how these collaborations are established, as they mainly rely on a snapshot view of them. Hence, while interorganisational partnerships have been seen as having great potential for value-creation, there has been little investigation trying to explain why they hardly emerge in underdeveloped Innovation Systems.

In the context of more advanced economies, there has been extensive research into the formation of networks and of R&D consortia specifically. A large stream of this literature has focused on the motives to collaborate and how they alter the initial settings and outcomes (i.e. Hagerdoorn, 1993, Chung, Singh and Lee, 2000). A less common perspective has put emphasis on the formation *process* itself, trying to identify the steps leading to the establishment of the alliance. These studies typically name a myriad of 'initial conditions' in which such arrangements are able to flourish. Yet these 'initial conditions' are normally associated with organisational features or practices, such as the partners' routines (i.e. Doz, 1996; Doz *et al.*, 2000) and not to the broad institutional environment in which such relations are embedded.

This paper contributes to this area of research as it sets to investigate how technological cooperation is established in Brazil. Institutions are the analytical focus elected for addressing this question. That is, the aim is to examine the role of institutions in the formation process of interorganisational collaboration (specifically of R&D partnerships[2]). As a point of departure, I

[2] 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).

make the point that institutions (in the sense of habits and routines) act as a **condition** for and (probably) as an **effect** of collaboration, as figure 1 illustrates. Given that, I propose the following research question: *how do institutions impact the formation process of R&D partnerships and thereby co-evolve with it?*

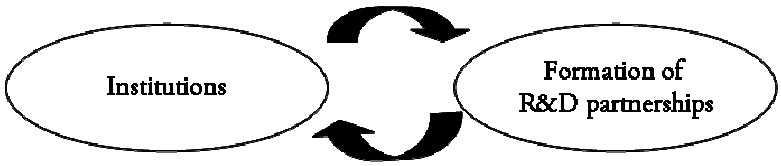

Figure 1: Institutions as a Condition for and an Effect of Collaboration
Source: Author's elaboration

Drawing on a process study of a number of interorganisational collaborations, 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 R&D partnerships. They suggest this is a co-evolutionary (time-dependent) process, which is able to flourish out of the practice of sharing knowledge with others, 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, which is complemented by the variables proposed in 3. Section 4 outlines the methodological considerations and the cases studies, which are described and analysed comparatively in section 5. The discussion of the research findings is presented in 6, followed by the conclusions of the study in 7.

2 Institutions and Innovation

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. 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 (Campbell and Pedersen, 2001; Gregersen, Johnson and Segura, 2005; Nelson, 2008).

Thus the idea that "institutions matter" has been widely accepted within various traditions of research. In social sciences, four generic approaches of institutional analysis can be distinguished according to the problematic and method of inquiry they subscribe to – 'rational choice', 'historical institutionalism', 'organisational institutionalism' and 'discursive institutionalism' (Campbell and Pedersen, 2001)[3]. Each one cuts across economics, sociology and political science. Briefly, 'rational choice' paradigm is rooted in neo-classical Economics and is concerned with how rationally motivated actors solve problems of exchange. It encompasses transaction-cost, principle-agent and game-theory approaches, having North (1990) as one of the

[3] These four approaches represent the new forms of institutional analysis, also known as neoinstitutionalism, since they descend from an old version of institutionalism developed in the late XIX century lead by John Commons, Thorstein Veblen and Wesley Mitchell (Campbell and Pedersen, 2001).

main exponents. ‘Historical intuitionalism’ originates from Marxist and Weberian political economy, focusing on how variations in institutions shape the actors’ capacity for action, policy-making and institution-building. It conceives processes of change as guided by the political and economic interest of actors and as underpinned by disputes and crisis. Central to this perspective is the idea that institutions that guide decision making reflect historical experience. ‘Organisational intuitionalism’, on the other hand, seeks to understand how rationality and the rationalisation of institutions are culturally and cognitively constructed and legitimised. Recognising that organisations are not always rational, scholars in this tradition seek to understand how the norms and the values from the environment impact organisations. They argue that organisations act appropriately according to their cultural environmental rather than instrumentally according to their official goals. Powell and DiMagio (1991) are a key reference within this line of research. It originally springs from phenomenology, ethnomethodology and cognitive psychology, being primarily developed by sociologists. Finally, ‘discursive institutionalism’ is a tradition initiated by Foccault (1969) which deals with how institutions are constituted, framed, and changed by language codes and discursive structures (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). Despite these developments, 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; iii) the unknown process of institutional change. As a result, he claims that institutions have not been made a useful analytical concept yet.

The present paper is aligned with the research agenda of ‘historical institutionalism’ in the sense that it seeks to identify institutions which affect technological cooperation and through which mechanisms they operate (specifically in a fragmented Innovation System such as the Brazilian one). In other words, how institutions enable, empower, constitute and constrain action. The point of departure is the definition proposed by Edquist and Johnson (1997:46): “institutions are a set of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals and groups”. According to this conception, institutions are social phenomena that clearly differ from concrete entities like any given company (regarded as organisations).

This perspective draws on Veblen’s legacy in the sense that behaviour is said to *follow* a regular pattern – a set of rules, norms of social behaviour and procedures – and not only to be *constrained* by it (the ‘rules of the game’ in North’s (1990) terms). This implies that human conduct is not guided by informed rationality, and therefore that the so-called “embeddedness view” of institutions is accepted. In the words of Coriat and Dosi (1998:6): “under the heading of the embeddedness view (…), institutions not only ‘parameterise’ or ‘constrain’, but, given any

one environment, also shape the 'visions of the world', the interaction networks, the behavioural patterns, and, ultimately, the very identity of agents".

Accepting this perspective thus implies attributing to institutions 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 and Johnson, 1997). They determine what patterns of behaviour are prominent and which ones are dissuaded in society – a differentiation which is imperative in contexts where the effectiveness of the actions of some agents depends on the behaviour of others (Nelson, 2008).

Four distinct roles are attributed to institutions in fomenting and facilitating the dynamics of innovation, accordingly: i) they reduce uncertainty and instability by providing information; ii) they act as conflict managers, allowing cooperation; iii) they provide incentives for economic agents; iv) they channel resources to innovative activities (Edquist and Johnson, 1997). This is not to say that institutions lead to purely positive sum games with regards to innovation or are necessarily efficient. The political and power dimensions underpinning institutional structures cannot be neglected, since they are not necessarily beneficial to all. There are strong elements of 'path-dependency' in them, indicating that once people are on a particular institutional path, they tend to stick to it rather than shift abruptly to another one (Campbell, 2004).

Furthermore, it is important to point out that institutions are not necessarily inertial structures hampering change, but are often connected to processes of economic change. This paradox is related to the widespread notion of institutions as rather stable, rigid and lasting structures acting towards the prevention of innovation. Nonetheless, institutions are also liable to change "as the result of the interactions leading to new knowledge" (Johnson and Nielsen, 1998: xiv).

In conclusion, institutions are understood in the sense of habits, routines and systems of meaning which mould the social context in which firms interact, alongside with their organisational capabilities (there are implications at the macro and micro levels). The subsequent section scrutinises this argument, identifying institutions which are said to impact the emergence of interorganisational collaboration.

3 Institutions Supporting Interaction and Cooperation

The broad conception presented in section 2 implies understanding the institutional environment as very complex and comprehensive. For the purposes of the present research, it was important to narrow down the scope, so that the fieldwork could become feasible. In this section the following question is addressed: *What institutions affect technological cooperation within Innovation Systems?*

Some scholars have worked to elucidate this issue. Most agree on those elements directly involved in the production and diffusion of scientific knowledge, which are often associated with the R&D apparatus or with the educational systems. However, the pertinence of other elements such as the system of industrial relations, the labour market regimes or the connections between industry and finance has been rather debatable. The empirical studies in the field remain

relatively scarce and a review of this literature indicates that there are multiple ways of assessing the institutional arena (Casper and Kettler, 2001, Coriat and Weisntein, 2002, Gregersen, Johnson and Segura 2005, Nelson 2008). Besides, prior research has not addressed explicitly institutions which enable or constrain interorganisational relations and cooperation throughout the innovation process.

I thus propose the analysis of three elements which I believe have a major impact in forging close ties among organisations and thereby the establishment of cooperative projects of R&D, namely: 'Knowledge Transfer Practices', 'Research Career Structures and Work Norms' and 'Access to Finance'[4]. They are represented in figure 2 and then explained thoroughly:

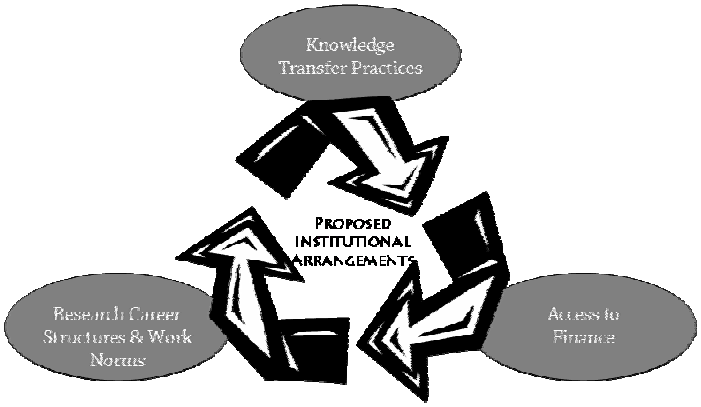

Figure 2: Interdependent Institutions affecting Technological Cooperation
Source: Author's Elaboration

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 (the quality of the country's basic research), 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. As Casper and Kettler (2001) argue, transfer practices must extend beyond simple licensing protocols and encompass a myriad of supporting resources, incentives and procedures. 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 the most formal institutions are 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. For instance, the way relations are established (informally or endorsed by detailed contracts), how interests are negotiated, the importance

[4] These variables were developed from literature review (deductive process), although they are unique in the sense that they have not been elaborated by other authors previously. These three sets have been formulated because they determine the way knowledge, interests and other resources (i.e. money) are coordinated in interorganisational contexts for the generation of linkages among partners. I conceive them as interdependent variables, even though cause and effect relations are not a priori determined.

assigned to intellectual property rights and the extent to which information is shared when it bears strategic content.

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, 2006), 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 *et al.*, 2000). According to Lam (2006), 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 patterns. Besides "recycling" the supply of qualified personnel, they foment the establishment of formal and informal linkages among professionals of a particular field or sector. The building of social ties is so 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. It is through their linkages that firms are able to mobilise external sources of competencies. 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, 2006).

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'.

Another important element to be considered when examining the careers of scientists is their ability to relate to peers outside their domain of expertise. This is because in interorganisational contexts, discrepancies may emerge when people of different academic backgrounds are put to work together. In such cases, epistemological issues may flourish. Therefore the researchers' degree of communicative openness to other scientific communities is crucial, for very often distinct bodies of knowledge need to be combined. This degree of openness is intrinsically associated to educational systems in the extent to which they provide the opportunity for cross-disciplinary formation for scientists. Furthermore, it is related to the motivation of scientists to establish network linkages.

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. 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[5]) 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.

Table 1 provides an overview of the variables I propose and which have informed my empirical research, as presented in the upcoming sections[6]:

[5] 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.

[6] 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 et al. (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

4 Research Approach

Following the premises of process research approach[7] (Pettigrew, 1990), 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 methodological choice is justified by the premises of the research itself,

[7] For the variables proposed, I do not define causal effects a priori (so-called "variance approach"). In contrast, I adopt a process approach, in which there is no model conceived a priori which could indicate the mechanisms or relationships between the elected variables and the outcome (i.e. the establishment of the partnership). Rather the aim was to understand how and why the events develop the way they did.

which is to investigate the role of the institutional environment on arrangements where cooperation did exist.

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)[8]. On the same basis as the Yale and Carnegie Mellon Surveys, the MG Survey collected a set of figures from these 140 companies, such as sources of information for innovation, patterns of interaction with universities and investments in R&D (Albuquerque *et al*., 2005). From this database, possible candidates 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 from the following sectors: Mining, Food Industry, Chemicals, Basic Metallurgy, Electrical and Electronic Material, Medical and Precision Instruments.

The exploratory (or pilot) interviews, whose goal was to check the existence of on-going cooperative R&D partnerships, constituted the first contact with the companies. In total, 13 interviews were carried out in this phase (during September-October/2006), which encompassed 12 companies (one refused to participate due to an internal restructuring process). At this stage, all interviews were carried out through telephone (mostly with R&D managers) and were tape-recorded. They ranged from 20 to 45 minutes. As a result, six potential cases were identified. Since this research does not focus on a particular sector, companies of the same sector had to be 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, the elected three companies comprised three cases in different sectors: Basic Metallurgy, Chemicals and Mining.

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

[8] 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 (Albuquerque *et al.*,2005).

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 four cases, which are discussed in detail in section 5:

TABLE 2
Summary of Case Studies

Partnership Purpose	Participating Organisations*	Number Interviews	Interviews per case
Research and development of a vaccine against bovine ticks	PharmaVet S.A.	2	4
	University A	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	
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

5 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.

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 PharmaVet 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. Its demand is justified by the fact that the effectivity of existing vaccines remains very limited (20% reduction in the number of infested parasites).

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. 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 researchers.

2. <u>Refractory Compound for Steel Production</u>

a) *Overview*: this partnership is formed by a steel producer, its supplier of refractory ceramics 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 overall collaboration (he develops several other projects with each firm). His eventual costs such as trips are also shared among participating companies. There is no government funding.

b) *Background*: In spite of being the first time the partners establish a formal project which involves all three 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. So, although we have not worked in such a formal way as it is now, we have always worked in high 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., that 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.

3. Indium Processing

a) *Overview*: the partners are a large corporation from the mining sector, MiningCo, a public research centre specialised in nuclear technology (Nuclear Power Research Centre, NPRC henceforth) and a public university, who contributes informally to the project this partnership. The partnership aimed at developing processes for the extraction and the production of Indium, a by-product from MiningCo's plant which has 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 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 got 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 purse his master and PhD 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. 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. 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. Nonetheless, the process can be regarded as an 'incremental innovation' in the sense that it was adapted to the company's specificities, but already existed in the world.

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. Table 3 below presents a summary of the effects of the three institutions upon the formation process of each partnership, which are then examined in detail:

TABLE 3
Summary of Data Analysis

Institutional arrangement	Vaccine Bovine Ticks	Refractory Compound	Indium Processing
Knowledge Transfer Practices	++	++	++
Research Career Structures & Work Norms	+	++	++
Access to Finance	++	o	o

Source: Author's elaboration
Note: ++: very important
+: important
o: not important

Firstly, with regards to 'Knowledge Transfer Practices', the cross-case examination has shown that collaboration between academia and industry is not an established procedure or tradition in the country. In general terms, the research groups have difficulties in dealing with property right issues or in establishing effective mechanisms of knowledge transfer. Evidence came from the fact that the Technology Transfer Offices played no role in any of the cases examined – although all universities reported to have had this sort of supporting organisation. The recurrent comment was that they were very incipient and inexperienced. The exception in this regard was the NPRC, which had a specific department to deal with collaboration and which appeared to be helpful in arranging the research contracts.

Yet all organisations investigated in the fieldwork appeared to have developed 'knowledge transfer practices' to different extents[9]. 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. 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. The latter dimension is decisive also to the development of knowledge sharing mechanisms and to the way behaviour is guided and addressed among partners. As stressed by Doz *et al.* (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 plays with regards to the development of 'knowledge transfer practices'. In all cases, cooperation evolved over time – from sporadic agreements (i.e. on-time consultancy services) to more sophisticated ones. For

[9] 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.

instance, in the *Refractory Compound* partnership, the two companies started with a typical user-producer interaction 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 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 (2006) 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)[10]. They were the crucial actors at the interstices of knowledge and organisational boundaries, acting towards the integration of the diverse frames of mind. 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 the network formation process, as they were able to reconcile such intrinsic divergences. In this way, the present research brings 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 can be integrated in interorganisational contexts through the effort of 'linked scientists'. Moreover, the evidence suggests that the 'linked scientists' have well developed 'integrative capabilities'. In the terminology of Owen-Smith *et al.* (2003), 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.

Other authors have pointed out the importance of such figures. Doz *et al.* (2000), for instance, have called them the "triggering entity". This paper does support the argument of Doz *et al.* (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.

This is an important point, since the hybrid career patterns were found to be much more of an exception rather than the rule in Brazil. The presence of 'linked scientists' was not said to be 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. 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

[10] 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, which lessened the need to integrate knowledge (basic science to technological applications).

repeatedly mentioned as an important constraint, for the researchers were evaluated by the different government agencies exclusively according to their number of publications.

Hence the career perceptions and professional values of the scientists interviewed 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 suggests a very clear distinction between the public and private sectors. Whereas the firm-based researchers reported not to have any financial constraints to their activities, the university researchers did complain about the insufficiency of resources and about the difficulties in obtaining them. Collaboration proved to be an important means of guarantying funds for the research projects and for laboratory equipments. As a result, it was decisive in the case of the *Vaccine*, but not important in the remaining ones.

Moreover, the recent changes in the government strategy of financing research were very significant. On the one hand, there has been an upsurge of funds directed to collaborative projects between university and firms, which also require a financial counterpart from firms. On the other hand, there have been important financial cuts in the budget for science and technology, making the access to funds extremely competitive. The analysis of the cases suggests that these changes have already had an impact. As discussed in the case *Vaccine*, the motivation of the university research team to contact the company was to increase the odds of obtaining funds with CNPq. Although this strategy can positively affect the emergence of collaboration, I want to call attention to the fact that this can become very artificial as well. In the long-term, it can shape the production of knowledge in such a way that only 'downstream' science (the one closer to commercial application) is valued and financed, letting aside the equally important production of 'upstream' scientific research (that is closer to basic research). In this matter the point of view of *diversity* is supported once more, in the belief that different financial arrangements are needed for science in order to accommodate the production of distinct bodies of knowledge.

6 Research Findings

This research has explored the impact of institutions in the formation process of technological cooperation 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.

My point has been 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 3, the results suggest that two crucial elements of such context are 'knowledge transfer practices' and the connecting effort of 'linking scientists'. First of all, the development of systems and procedures for knowledge sharing with external parties has been recognized as absolutely crucial. They provide the means for the collaboration, conditioning the knowledge production process. They are 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). This is because linked scientists bring 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, since they are able to reconcile the divergent work modes of academia and industry and to move back and forth from basic science to commercial applications. Several dimensions influence the endeavour of linked scientists – their mobility between industry and university, entrepreneurial culture in the academia, employment practices and training policies of R&D personnel in companies. 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 relevant in only one of the cases investigated. I argue it functions only if the other elements of the context are in place.

Furthermore, figure 3 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 7-10 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.

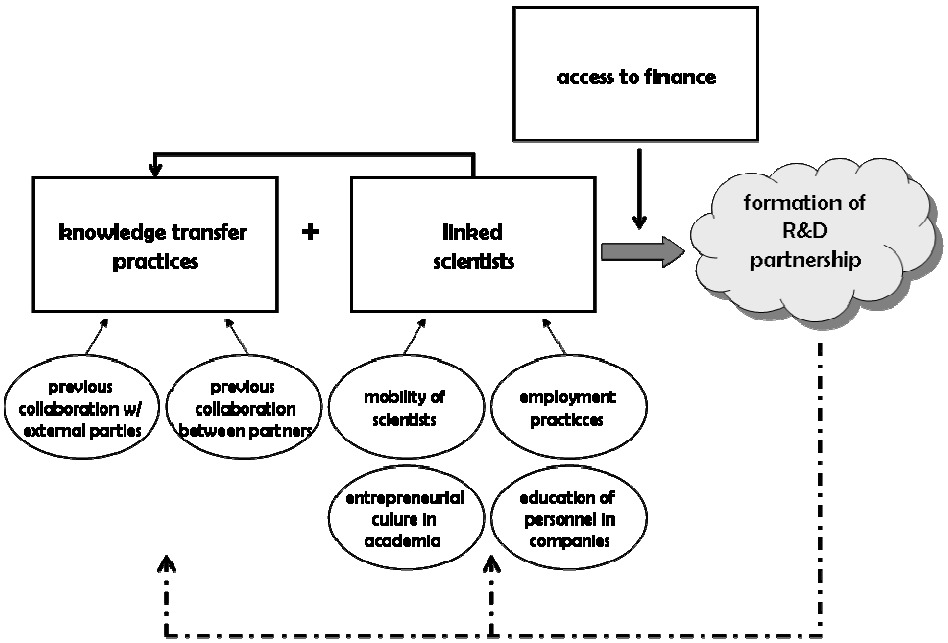

Figure 3: The role of institutions in the formation process of R&D partnerships: an illustration of main research findings
Source: Author's elaboration

Another central finding of this paper is the understanding of how institutions operate and therefore how they play out at the micro-level. Regarding 'knowledge transfer practices', a number of mechanisms have been identified. The negotiation of clear contracts, for instance, was present in two cases – *Refractory Compound* and *Indium Processing*. As they set the project milestones and the work pace, they were crucial for the alignment of objectives and expectations between partners. Publishing rules were also discussed in the beginning of collaboration in these cases. Another mechanism employed was the a priori establishment of routines for project follow-up and for knowledge sharing in general. This was made clear in the consortium *Vaccine*, in which the partners discussed the regularity of meetings and the division of tasks from the very start. Lastly, the formation of shared lexicon and cognitive meanings was a key instrument for the *Indium Processing* case, in which the scientist from NPRC gave special training to the employees at MiningCo in order to level the knowledge about solvent extraction techniques.

In terms of 'research career structures and work norms', the companies investigated have used a several means to get access to the people working at the interstices. Among them: i) employment of young scientists who have recently concluded their Ph.D.'s (PharmaVet); ii) employment of part-time researchers who are affiliated to other organisations (MiningCo); iii) bestowal of research grants and scholarships to graduate students from universities (Steel Corp., Refractory Materials and MiningCo); iv) investments in the education of the personnel, including master's, MBA and Ph.D. programmes, as well as participation in conferences (all companies); v) establishment of linkages with 'entrepreneurial professors' or symbolic figureheads (Steel Corp., Refractory Materials).

In order to guarantee 'access to finance', companies have not only applied jointly to government grants (*Vaccine* case), but also have purchased laboratory equipment for universities and

provided the full funding of R&D projects (*Indium* and *Refractory Compound* partnerships). The payment of researchers' work hours was used to attract scientists and thereby to supplement their salaries, which are acknowledged to be depreciated. Another means companies employed to have access to research funds was to apply to tax benefits with the government.

Table 4 summarises the set of mechanisms which seem to be working for the linkages between macro and micro factors which clarify the dynamics between the different analytical levels:

TABLE 4
Linking macro to micro factors: results from the case studies

Institutional arrangements	Micro mechanisms employed at the firm level
Knowledge Transfer Practices	1.Establishment of clear contracts that define the project goals, timeline and ownership of property rights 2. Consolidation of joint routines supporting knowledge sharing 3. Negotiation of publishing rules 4.Formation of a common lexicon and shared cognitive meanings
Research Career Structures and Work Norms	1. Employment of young scientists (recent PhD's) 2.Employment of part-time researchers affiliated to other organisations 3.Bestowal of grants and scholarships to graduate students from universities 4. Training of the personnel and participation in conferences. 5.Establishment of linkages with 'entrepreneurial professors' or star scientists
Access to Finance	1. Joint application to government funding programmes 2.Tax benefits 3.Purchase of laboratory equipment for universities 4.Provision of supplements for researchers' salaries 5.Full funding of R&D projects

Source: Author's elaboration

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 I would expect that some results are

similar 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 very limited.

7 Conclusions

The present study has examined the issue of how institutions interact with organisational structures and processes to support collaboration in interorganisational contexts. 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. It has uncovered the processes and mechanisms underlying their emergence, showing that they can be related to the proposed institutions. In particular, the development of practices related to knowledge sharing and the connecting effort of linked scientists were recognised as crucial pre-requisites for the establishment of technological cooperation in Brazil. Besides, the institutional arrangements seemed to be developing together with the R&D partnership in a dynamic and interconnected fashion, constituting a co-evolutionary process of change. Furthermore, this research has made an important observation about the presence of inter-temporal dynamics in collaboration. All collaborations examined developed from sporadic relations to more sophisticated arrangements characterised by joint creation of knowledge. Another contribution has been to identify and unpack mechanisms that appear crucial in helping to explain how institutions actually work at the organisational level and thereby how change occurs. All in all, the cases studies provided the opportunity to investigate the phenomena of technological collaboration behind the figures collected by the MG Survey – 'a zooming-in' – in the belief that different methodological approaches can enrich and complement each other.

The present study thus extends the existing research by shedding light on the role of institutions throughout network formation processes. In this way it is aligned with the 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. (2005) Interactions between firms and universities in an immature system of innovation: a survey of industrial R&D performers firms in Minas Gerais, Brazil. *Paper presented at the Third Globelics Conference, South Africa*. Available at: http://www.globelics.org. January 12, 2006

AROCENA, R. & SUTZ, J (2000) Looking at National Systems of Innovation from the south. *Industry and Innovation* 7 (1), p.55-75

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

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

CAMPBELL, J. L (2004) *Institutional Change and Globalization* Princeton University Press: Princeton, N.J.

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

CASSIOLATO, J.E.; BRITTO, J.; VARGAS, M. (2005) Arranjos cooperativos e inovação na indústria brasileira. In: De Negri, A.; SALERNO, S. (org.) *Inovações, padrões tecnológicos e desempenho das firmas industriais brasileiras.* Brasília: IPEA.

CASSIOLATO, J.E.; LASTRES, H.M.M. (2000) Local Systems of Innovation in Mercosur Countries. *Industry and Innovation* 7 (1), p. 33–53, June 2000

CHUNG, S.; SINGH; LEE, K. (2000) Complementarity, status similarity and social capital as drivers of alliance formation. *Strategic Management Journal* 21, pp.1-22.

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

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

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

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

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

FOCCAULT, M. (1969) The archaeology of knowledge and the discourse on language. New YORK: Harper Colophon

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

GREGERSEN, B.; JOHNSON, B.; SEGURA, O. (2005) Institutions and learning capabilities in a development perspective. Chapter 4 in forthcoming *"Systems of*

Innovation and Development – Central American perspectives"

HAGERDOORN, J. (1993) Understanding the rationale of strategic technological partnering: interorganisational modes of cooperation and sectoral differences. *Strategic Management Journal*, 14, n.5, p.371-385.

JOHNSON, B.; NIELSEN, K. (1998) Introduction: institutions and economic change. In: NIELSEN, K.; JOHNSON, B. (eds.) *Institutions and Economic Change: new perspectives on markets, firms and technology.* Edward Elgar, London.

LAM, A. (2006) Knowledge Networks and Extended Internal Labour Markets: Academic Scientists in Industry-University Links. *Paper presented at DRUID Summer Conference*, Copenhagen, CBS, Denmark, June 18-20, 2006. Available at http://www.druid.dk September 20, 2006.

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

LUNDVALL, B-Å. (ed.) (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter, London.

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

NELSON, R. (2008) What enables rapid economic progress What are the needed institutions? *Research Policy* 37, p. 1–11

NELSON, R.; SAMPAT, B. (2001) Making sense of institutions as a factor shaping economic performance. *Research Policy* 44, p.21-54

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

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

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

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

POWELL, W.W.; DIMAGGIO, P.J (eds.) (1991) *The New Institutionalism in Organizational Analysis*. Chicago: University Press

RAPINI, M. S. (2005) Interação Universidade-Empresa no Brasil: evidências do diretório dos grupos de pesquisa do CNPq. Texto para Discussão; 251. Belo Horizonte: UFMG/Cedeplar, 2005