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Between Multinational Companies and Sectoral Innovation Systems: Patterns in the Organization of Innovation in Subsidiaries

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Abstract

This research investigates patterns in the organization of innovation in subsidiaries and the role of innovation projects in integrating knowledge between the multinational companies and technological partners in the host innovation system. The analysis describes and compares different configurations used in innovation projects by large subsidiaries of multinational companies and their key technological partners in the Brazilian Information and Communication Technology (ICT) manufacturing sector. Rather than best practices, the comparison of configurations in the organization of innovation projects provides a way to examine the complexity of the subsidiary development and the dynamic alignments and misalignments between the evolution of the multinational companies and sectoral innovation systems.

1. Introduction

The internationalization of R&D activities results in new opportunities and increasing interdependency between multinational companies and the host country innovation systems (Dunning 1994; Cantwell 1989). However, particularly in developing countries, many important questions remain open about how subsidiaries may realistically sustain their developmental path inside the increasingly complex R&D networks in multinational

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companies (UNCTAD 2005). There are still crucial questions about the dynamic process by which subsidiaries evolve in their R&D activities and operate as a boundary-spanning mechanism between national and international networks in developing countries (Ernst & L. Kim 2002; Birkinshaw & Hood 1998). The possible benefits of engaging in these global innovation activities is hindered by economies of scale in the innovation process, communication and co-ordination problems and concerns of knowledge leakage (Hakånson 1992; Patel & Vega 1999; I. Zander 2002; Cantwell & Piscitello 2002; Cantwell & Santangelo 2002).

This paper argues that the existing understanding on the process of integration between multinational companies and host innovation systems in developing countries remains fragile. The recent literature has acknowledged that the integration of MNCs is a multilateral and multidimensional rather than linear development process (von Tunzelmann 2004). The successful integration between multinational and national production networks depends upon the dynamic action of a decentralized netwo

rk of governance, entrepreneurship and innovation (Radosevic 2005; S. Kim & Tunzelmann 1998). This contrasts with the existing literature as the typologies used for defining the knowledge-based interactions between international and host economies tend to oversimplify this complexity and conflicting aims of different stakeholders in the innovation process (Kuemmerle 1997; Narula & Zanfei 2004; Dunning 1994)(Rugman & Verbeke 2003)(Lundvall et al. 2002; Mani & Romijn 2004). A richer understanding of the complex process of alignment between environment, organizations and performance requires an in depth analysis of the underlying configurations involving both the multinational and organizations in the host sectoral innovation system (Malerba 2002).

A project-level analysis of the different networks developed around subsidiaries can provide a richer insight in the evolutionary organizational growth of multinational companies into developing countries. This paper is an exploratory study of the common configurations in innovation projects between multinational companies and sectoral innovation systems in developing countries. This study compares different forms of organizing innovation projects in 11 key subsidiaries of multinational companies[2] and 11 of key technological partners (i.e. educational and research institutes) in the Information and Communication Technology (ICT) manufacturing sector in Brazil. This comparison is based on a combination of 35 in-depth interviews and analysis of archival data on 2722 projects internally and in partnership between 1997 and 2003. This sample of projects amounts to more than $650 million dollars (1.3 billion reais). The average innovation project size is around 250,000 dollars (500,000 reais) and some projects reached ~25 million dollars (50 million reais).

The analysis takes advantage of a specific context provided by the sectoral policies applied to the sector that induced expenditure in innovative activities by in the sector, and subsidiaries in this sector in particular. Acknowledging the need to retain and expand technological capabilities after the end of import substitution policies in the early 1990s, specific incentives to collaborative innovation activities where created to support high levels of investments in innovation in companies manufacturing locally ICT products[3]. Tax incentives required that companies that had approximately 5% of national sales expended in innovative activities. Part of this expenditure needed to be in partnership with education and technological institutes. Since 1993, this institutional framework, known as ICT Law, promoted higher investments in R&D than usually expected from these companies in developing countries. As the main markets consolidate among few multinational companies, the sectoral policies applied to the sector resulted in a significant amount of resources to innovative activities in subsidiaries of multinational companies.

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[2] The companies taking part of the sample are Celestica, Dell, Ericsson, Furukawa, Hewlett Packard, LG, Lucent, Motorola, Northern Telecom, Siemens and Solectron. The technological partners interviewed are FINATEL, CITS, Eldorado, Informat, Brisa, Fitec, CEFET-PR, CPqD, Cenpra, Unicamp, IPT.

[3] The ICT sector was defined in relatively broadly sense in order to account for interdependencies and linkages spanning over computers, telecommunications equipments and mobile handsets. It just includes manufacturing firms both national and foreign with certified level of local production. For more details, see (Brasil 1998; Brasil 2003b; Brasil 2003a; Brasil 2004; UNCTAD 2005)

It resulted in a large number of different initiatives and experimentation with different forms of technological capabilities, collaborations and decentralized governance structures in the sector. The recent analysis of the sector shows that despite the large number of projects, a number of challenges remain and conflict of interest between national and international actors in the sector is high (Tigre & Botelho 2001; Schjolden 1999; Worden 1997; Queiroz, Zanatta & Andrade 2003; Campos & Teixeira 2004). Rather than a linear process of accumulation of technological capabilities, the knowledge flows involved unbalance development of different stakeholders, resulting in suboptimal organizational structures. Therefore, this context provides an important natural setting for investigating a variety of configurations emerged in the sectoral system.

The paper is organized as follows. The second section briefly discuss the nature of innovation in subsidiaries, their role as boundary-spanning vehicle between knowledge in international and national networks of actors, with a particular focus on their behavior in developing countries. The third section discusses the framework of used for the analysis and the possible contribution of a configurational perspective to the analysis of inter- and intra-organizational networks of subsidiaries. The fourth section details de methods used for developing the proposed taxonomy of configurations and the data sources used for this research. This fifth section provides a description of the main configurations identified in the sector. The last section discusses some implications and propositions resulted of this analysis followed by some conclusions.

2. The development of the multinational knowledge network and the integration with the host innovation system

The early models of the MNC assumed that a relatively monolithic planning and decision-making process about technology. Headquarters would develop most of the innovation and control closely R&D operations abroad that would support absorption of technology and adaptation to different markets (Vernon 1966). Most of the initial literature focused almost exclusively on the specific on foreign direct investment, that some alludes to the headquarters' decision to invest in different locations. The geographic, cultural and epistemological distance between policy-maker in host countries, particularly developing ones, and decision-maker in headquarters of multinational companies put significant constraints on opportunities for informed negotiation. Most of the political debate focused on possible benefits of open in relation to close regimes in relation to FDI.

The premise of centralized decisions about technology in the multinational company, mainly valid for most of the cases at the time, were challenged as more complex forms of multinational corporations evolved during recent decades. It was observed that the headquarter ability to influence subsidiary strategy cannot be taken for granted (C.K. Prahalad & Y.L. Doz 1981) and company needs to rely on their network of subsidiaries to provide the flexibility to manage these dual local-global pressures (Ghoshal & Nohria 1989). It is widely acknowledged in most of the companies that a level of flexibility at the subsidiary allows a better response of the multinational corporations to pressures in the local markets and needs to integrate activities globally (Bartlett & Ghoshal 1989; J.M. Birkinshaw 2003; Dunning 2000; Y.L. Doz, Bartlett & C.K. Prahalad 1981).

The possible impact of the MNC in the host country started to be discussed more and more in terms of the specific roles played by subsidiaries in the MNC network (Ghoshal & Nohria 1989). The function of headquarter became less related to direct control of organization form and/or technology used and more related to the coordination and alignment of strategic decision among differentiated subsidiaries (Ghoshal & Nohria 1989; I. Zander 1998){Doz, 1981 #297; Kuemmerle, 1997 #418}.

In this direction, the international management literature has been extremely prolific in the development of typologies that could distinguish the role of subsidiaries inside the multinational network. There many typologies emerged to define subsidiary roles in the network. Among the most widely recognized typologies is the distinction between Product versus market scope (miniature replica, product specialist, strategic independent) (White & Poynter 1984), competence versus strategic importance (resulting in the distinction between black hole, local implementers, contributor and strategic leader)(Bartlett & Ghoshal 1989), integration versus responsiveness (locally responsive, integrated product strategy, multifocal strategy)(C. K. Prahalad & Y. L. Doz 1987), knowledge flows and inflows (implementers, global innovator, integrated player) (Gupta

& Govindarajan 1991), autonomy and integration of activities (local implementers, specialized contributor, world mandate), and asset-exploiting R&D versus asset-augmenting R&D (respectively, R&D labs responsible for supporting production resources, learning from different markets and R&D labs interacting with leading technological sources) (Kuemmerle 1997; Narula & Zanfei 2004).

Although this stream of research acknowledges that different subsidiaries perform different functions, the general line of the typologies tends to point out to one "best role", that would have particularly special benefits to both multinational and host country. It has been observed that the ability of subsidiary to accumulate distinct technological capabilities fundamentally depends on specific characteristics of the host innovation system (Frost, J. M. Birkinshaw & Ensign 2002; Zahra & Dharwadkar 2000; Asakawa & Lehrer 2003; Phene & Almeida 2003). This has resulted in increasing competition among countries around the world to create a specific set of incentives and able to attract and/or turn existing R&D units in their territory into high-technology centers of excellence and world mandates.

However the process of change in the subsidiary development remained under explored (Birkinshaw & Hood 1998). The recent literature has focused on examining in greater depth the process by each subsidiaries develop their position in the MNC over time and the possible implications in terms of knowledge flows. Entrepreneurship in the subsidiary is increasingly encouraged inside the corporation as a way to achieve the balance between local and global demands (J. Birkinshaw 1995b). At the same time, it is observed that the accumulation of distinct technological capabilities is an important way by which subsidiary managers develop their position inside the multinational network(Egelhoff, Gorman & McCormick 1998; Zahra & Dharwadkar 2000; White & Poynter 1984; Zanfei 2000).

A subsidiary centered view of the multinational development has become particularly important in the examination of the interaction between multinational companies and host countries. However, following from a resource-base view of the firm, the literature shows that subsidiary development is limited by the availability of resources in excess of the minimum necessary to produce a given level of organizational output (Penrose

1995)(Jarillo & Martinez 1990). Strong mechanisms of control hinder the abilities of subsidiaries to innovative, while excessive organizational slack may result in wasteful experimentation and empire-building (Nohria & Gulati 1996). Evidences show that a certain amount of organizational slack is important to reduce conflicts, to reduce information processing needs, to promote political and strategic behavior (Bourgeois 1981). This constrains will tend to be particularly relevant in developing countries. The recent empirical economic literature found contradictory results in terms of technological spillovers from FDI in developing countries (Iacovone & Perini 2004). The existence of advanced forms R&D laboratories in subsidiaries became considered more and more a key element in promoting the flow of knowledge between the multinational sources of technology and the local industry (Birkinshaw & Hood 1998; Ghoshal & Bartlett 1988).

Even when advanced R&D laboratories exist, there might be organizational mechanisms isolating the knowledge in the multinational company from the knowledge embedded in the host innovation system. Some authors suggested that the ability of MNCs to act as a boundary-spanning vehicle between global and local knowledge is overemphasized (Sölvell & I. Zander 1998). As pointed by Zanfei, "The development of the MNC internal network relies heavily on, and favors, the growth of external, locally embedded networks, which in turn require increasing degrees of autonomy for decentralized units. This increasing autonomy continuously risks reducing incentives to circulate knowledge between units belonging to the TNC. Considerable, conscious effort is thus needed here too, in order to innovate coordination modes and prevent the whole network from collapsing" (Zanfei 2000).

There is a need to break into organizational boundaries. Empirical studies have shown that unlike simple transmission of operational information, the flows of know-how between units in the network require a complex and rich intra-firm communication channels (Ghoshal & Bartlett 1988). Knowledge flows would not just depend upon the richness of transmission channels, but also the subsidiary's knowledge stock and the motivational disposition to share knowledge of the originator, as well as the motivational disposition to acquire knowledge, and the capacity to absorb the incoming knowledge from the receptor (Gupta & Govindarajan 1991). In this context, projects are increasing recognized as an adequate framework by which knowledge can be created and shared and used to improve organizations (Hobday 2000).

Therefore, innovation projects can help us appreciate the knowledge diffusion inside and outside the corporation (Ruuska & Vartiainen 2005; Kogut & U. Zander 2003). At the moment however little is know about how different configuration among stakeholders in innovation projects may inhibit or encourage knowledge flows both between the subsidiaries and other actors in the multinational network and host country institutions. In this aspect, an exploratory project-level analysis is required to identify usual knowledge flows between multinational companies and host country innovation systems. Investigating the usual configurations in innovation projects may help us understand how complex tacit knowledge is diffused, adapted and recombined inside and outside corporations.

3. A project-level analysis of the interaction between MNCs and the host country sectoral innovation systems

The research approach used here is based on a configurational approach to the analysis of organizations. According to the organizational literature, configurations emerge from the interplay among context, structure and strategies and could be understood as "common alignments of elements" (Miller 1986; Miller 1996). Therefore, the configurational approach is an attempt to go beyond the idea of one variable at a time (usually associated with a contingency approach) towards a focus on the identification of some central themes that orchestrate the alignment among a great number of variables. It departure from the principle that there are recurring patterns in any organizational setting, therefore the possibilities the characteristics would be limited to the natural trend towards these set of patterns (Meyer, Tsui et al. 1993).

This congruence towards a set of patterns would happen based on the following evolutionary principles. First, the environment will select out combinations of structure and strategy that are not adequate to specific contexts. Second, just a limited number of configurations will result in relatively harmonic relations among its constituent parts. Third, organizations would tend to change between (or create a new) discrete types of configurations relatively rapidly while these discrete configurations would tend to be reasonable stable over time (Miller 1986; Miller 1996).

Therefore, understanding these set of patterns would help us to simplify the organizational analysis to relatively simpler "building blocks" and, at the same, appreciate the complexity in the network formed by superposed structures. This set of configurations should provide a basis to go beyond the examination of each one of the specific characteristics of the organizations that may provide sustainability to the networks in specific environments. In addition, by definition, configurations are assumed to have reasonable stable nature and the identifying them in a specific settings provide us with a relative predictive power without excluding the role of agency. Following these evolutionary organizational principles, this framework suggests that examination of the characteristics of the recurring configurations provides a basis to discuss institutional and organizational changes necessary to promote the sustainability of the decentralized knowledge networks and integrating agency and structure.

In principle, these set of patterns could be defined from both a top-down manner (typologies), where possible configurations are developed based on conceptual frameworks (see J. Birkinshaw 1995a), or derived from bottom-up empirical observations, resulting in taxonomies. The latter approach is used in this investigation. As previously discussed, the existing literature on the interrelation between multinational companies and local innovation systems both in international management and innovation studies tend to focus excessively on the first approach (i.e. based on theoretically driven typologies). Despite the relevant contributions of these typologies, this top-down has endogenous limitations as it tends to ignore the interdependence between organizational variables departing from a conceptually defined typology (Meyer, Tsui & Hinings 1993). The focus is this research is on developing bottom-up taxonomy of the possible configurations between structure and strategy in the organization of innovative activities. Although this is restricted to specific historical and contextual circumstances, this taxonomy should provide a solid basis for expansion and validation in different contexts and sectoral settings.

This paper argues that the principles of configurational approaches could have appealing complementarities with the concept of network alignment as applied in the analysis of the organization of innovation in knowledge networks (Joe Tidd 2001) and the sectoral innovation systems in transition (S. Kim & Tunzelmann 1998; von Tunzelmann 2004). The recent analysis of the innovation systems in these economies has pointed out limitations on market and state as source of sustainable organizational growth. The network alignment approach highlights the multiplicity of networks (i.e. global, national and local), resulting in the need for investigating multiple levels of governance. However, there are still no empirical studies at the project-level data trying to classify these different governance structures emerging from the interplay of global, national and local knowledge networks.

4. Methods and data sources

The following research questions guide the research: What are the organizational configurations in innovation projects formed between multinational companies and technological institutes in latecomer sectoral innovation systems? The investigation of the evolving configurations in the project based network was based on multiple case-studies. According to Yin, a case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 2003). Although case studies tend to be associated with exploratory research and the identification of possible propositions, case studies can also be used for an inductive development of theory (Eisenhardt 1989; Darwin 2003).

The selection of the cases was based on investments in innovative activities among those companies and research institutes involved in the Brazilian tax scheme for promotion of innovation in manufacturing companies in the ICT sector ("ICT Law")[4]. The Brazilian ICT Law provides a natural experiment and a valuable source of data to investigate the

[4] In collaboration with SEPIN/MCT, this research had access to details of 11,000 innovation projects declared in the sector between 1997 and 2003 from which collaborations between multinational companies and technological partners (Brasil 1998; Brasil 2003b)

project-level configurations between institutions, multinational companies and the local innovation system.

Exploratory case-studies on the innovation projects of 11 of the largest R&D laboratories in subsidiaries in Brazilian ICT sector and 12 of their main technological partners were developed. 35 R&D managers were interviewed in interviews that took 90 minutes in average. The interviews were conducted between June and September 2005 in 5 different locations in Brazil (Porto Alegre, Curitiba, Sao Paulo, Campinas and nearby cities, Brasilia). The interview used a combination of structured and open questions. The size of the R&D laboratories ranged from 10 to 600 people.

The sample of subsidiaries conducted 2722 projects internally and in partnership between 1997 and 2003 (an annually average of 29 projects per subsidiary). The average innovation project size is around 500,000 reais (250,000 dollars) and some projects reached 50 million reais (~25 million dollars). The investments in innovation in this sample amounts to $1.3billion reais (~650 million dollars). The subsidiaries average annual budget was 15 million dollars. Table 1 shows the number of projects declared by different subsidiaries. Annex 1 highlights some of the projects examined and discussed with the different companies.

Table 1 - Subsidiaries and number of innovation projects identified between 1997 and 2003

COMPANY	Total
CELESTICA DO BRASIL LTDA	22
COMPAQ COMPUTER BRASIL IND. COM. LTDA	159
DELL COMPUTADORES DO BRASIL LTDA	53
ERICSSON TELECOMUNICAÇÕES S/A	193
FLEXTRONICS INTERNATIONAL TECNOLOGIA LTDA	73
FURUKAWA INDUSTRIAL S/A PRODUTOS ELÉTRICOS	155
HEWLETT PACKARD DO BRASIL LTDA	213
LG ELECTRONICS DE SÃO PAULO LTDA.	144
LUCENT TECHNOLOGIES DO BRASIL INDÚSTRIA E COMERCIO LTDA	113
MOTOROLA INDUSTRIAL LTDA	386
NORTHERN TELECOM DO BRASIL INDÚSTRIA E COMÉRCIO LTDA.	121
SIEMENS LTDA	858
SOLECTRON BRASIL LTDA.	232
Grand Total	2722

Using a structured diagram, interviewees were asked (i) to identify the intensity of the interaction of the specific R&D group in the subsidiary with 12 different possible groups of intra-firm, national or international stakeholders, (ii) how they organized their main projects and internal groups inside the R&D department and (iii) how the characteristics of these groups working in different types of innovation projects evolved. Whenever possible, usual and unusual innovation projects inside the R&D department were also discussed. Particular focus was given to when, why and how different groups emerged, how these groups are sustained, and where specific activities are conducted.

The information provided during the interviews was crosschecked with interviews conducted with partners and detailed description of the projects. Secondary data on key innovation projects were identified, observing their organizational characteristics and inter-organizational linkages. This allowed identifying usual stakeholders in each one of the configurations identified. This procedure allows mapping usual knowledge and financial flows inside innovation projects and usual aims of relevant stakeholders in specific configurations.

The combination of qualitative and quantitative data on multiple case studies led to 12 different configurations in 11 key R&D labs of subsidiaries of multinational companies and their 11 main technological partners in the Brazilian ICT. In average for each case, three of the most usual configurations were discussed in detail. The configurations suggested here (as indeed in any other study of organizational configurations) are not meant to fit precisely into individual organizations. In fact, each individual organization tends to be involved in a number of configurations and variations between the 12 constructs proposed. Some short examples about the innovation projects in subsidiaries and the technological partners are included in the description of different configurations[5].

5. Interorganizational configurations in the interaction between multinational and host country innovation systems

Twelve distinguishable organizational configurations emerged from the analysis of the innovation projects in 11 R&D laboratories and 11 key technological partners. They are subdivided in 3 different categories: (i) Internal Networks, configurations in this category are mainly led by the aims of the subsidiary. (ii) External Networks, configurations in this category are mainly led by technological partners. (iii) Integrated Networks, configurations involving intensive coordinated governance with different actors[6]. Table 2 introduces these organizational configurations in the different categories as they will be explored in this chapter.

[5] More details on the cases can be observed at Perini (forthcoming)

[6] For more details, on a quantitative analysis of the differences between these networks, see (Perini 2006)

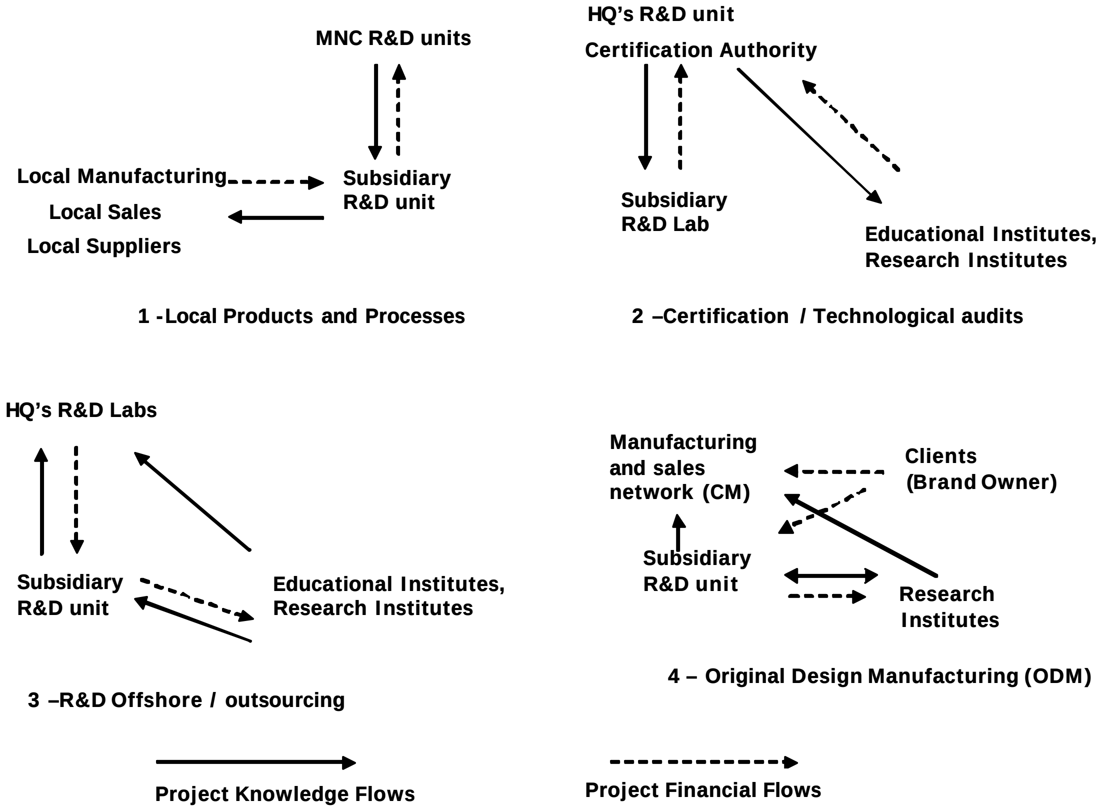
Table 2 - Common configurations in different project-based knowledge networks

Categories	Description	Common configurations
Internal Configurations	Innovation projects mainly organized inside the subsidiary and multinational company	?? Local Products/Processes ?? Certification and technical audits ?? R&D Offshore unit ?? Original Design Manufacturer (ODM)
External configurations	Innovation projects mainly associated with strong participation of technological partners	?? Sponsorship ?? Technological pools ?? Structuring/ Priority programmes ?? Technological Consortia
Integrated configurations	Organization of Innovation projects with integrating strongly internal and external networks	?? Corporate Venture ?? Global Mandates ?? Centers of Excellence ?? Technological scouting

5.1. INTERNAL CONFIGURATIONS - EXPLOITING THE MULTINATIONAL NETWORK

There are a number of c innovation projects developed mostly inside the subsidiary or MNC network and with a limited integration into sectoral networks. The key configurations included in this category are (i) local product/process configuration, (ii) audit/certification, (iii) R&D offshoring and the (iv) Original Design Manufacturing (ODM) model. These most common connections among partners configurations observed in the developing network are represented in Figure 1. The most common flows of resources (full lines) and flows of knowledge (dashed lines) are also represented in the different configurations.

Figure 1 – Internal configurations



The details of these models will be discussed in each one of the following sections.

Local products and processes

This is the simplest model of innovative activities developed by subsidiaries. The organizational configuration related to local product/process refers mainly to stand-alone and autonomous projects targeting specific niches identified by local marketing units or processes need inside the local operations, including manufacturing units. Most of the time this comprises of adaptive R&D activities, although in some cases the resulted in significant shifts from the original design.

The autonomous nature of this configuration is usually considered its main advantage by subsidiary managers. In some cases, these independent projects were even dubbed "submarine projects", as they were beyond the radar of the headquarters. This configuration is also considered a requirement for capacity building as allows the subsidiary to explore different technologies and components of the product and process. It allowed the experimentation of the technical group in areas considered relevant. In subsidiaries with limited R&D experience, this configuration was usually a direct result of availability of resources and internal technological opportunities perceived by small technical groups, creating or adapting products relevant to the national/local market at different points in time. However, these initial projects were necessary steps to develop teams.

Despite different levels of technical support from other R&D units inside the corporation, most of the products and processes developed did not have a clear integration with different departments in the subsidiary. When resources were allocated to R&D uniquely because of regulation requirements, the lack of organizational linkages of the R&D group, even inside the subsidiary, was evident. Resources were very volatile even for the largest groups, making it difficult to sustain the learning curves in these organizations. The commercial success of many of the local products reported was limited.

One of the strategies used was partnerships with different institutions that would already have considerable competence in product development. In some few cases, even shared intellectual property of the outputs were negotiated. However, most of the technological partners allowed inside the framework have themselves limited commercial capabilities. Nevertheless, the technical performance of, products created in the subsidiary were proofs of the subsidiary's technical qualification to the multinational network and national clients despite the lack of commercial success of most endeavours. Most of the independent product development was considered as a necessary learning process and it would hardly be accomplished with the specific institutional framework applied to the sector. At the same time, the same commercial failures showed subsidiaries that systematic interactions with existing clients and/or global strategies were a requirement. Despite the advantages of autonomy, increasing the actual impact on the overall organization performance would require

Certification and corporate technical audits

There are considerable entry barriers and substantial initial investments that needed to take place before stronger integration into global network can be accomplished. Different forms of proof are required in order to be acknowledged by key partners, even inside the multinational corporation. Most of the subsidiaries had groups focusing on internal and/or external *certification or internal audits*. The objectives of these activities were twofold. First, Certification was important to provide initial qualification to enter into the competition for projects with other units. Second, audits with different standards related to quality, technology or project management became a mechanism for learning good practices inside specific technological fields and improving organizational productivity.

These qualifications were first developed inside the groups in the subsidiary, and then extended to technological partners (mainly a selected group of private research institutes). However, given the high costs of these initiatives, the certification process were limited to a very small number of key local players. Most of these local players had also to invest themselves on their own qualification and certification process.

Offshoring R&D

Offshore R&D units became an important way to connect the local capabilities with the global R&D network (Chen 2004; Florida 1997; Kotabe 1990). Different strategies were used by subsidiaries to develop these units. Showing some of the early results in terms of local product development was fundamental. Some of them like HP and Siemens, used established internal markets of the multinational company where different units compete by internal projects[7]. Different subsidiaries offset these global linkages with their own resources. Offering "free lunches" provided a way of connected to new units.

[7] Sometimes the Brazilian subsidiary created this type of organization inside the organization, later was expanded to other units as in the case of Dell.

Some multinational companies indeed developed strong channels interconnecting with core nodes of the global R&D networks in the area (e.g. mobile handsets, switchers, etc). Despite the clear lost in autonomy, the connection with the corporation would guarantee resources to the local unit independently of shifts in the regulatory framework. The R&D offshore groups in the subsidiaries were particularly strong in software and system innovative activities. Although they compete with groups in other units, some of the local groups grow up to 500 engineers in these activities.

Some of the units however became trapped on the need to offset their participation in the global R&D network and received little compensation for the activities developed for the corporation. In hardware and semiconductors, however, subsidiaries faced limited scope for growth inside the intra multinational network given the strong competition with East Asian and Chinese subsidiaries. In these technological areas, local subsidiaries such as Siemens and Ericson had to downsize teams as other subsidiaries after the burst of the Internet bubble. As Asia specialized more and more in these activities inside the corporation, even in products for the local market, components related to semiconductors and hardware would be systemically outsourced from the local subsidiary to R&D units in Asia.

The cultural and organizational idiosyncrasies of each multinational company played a crucial role. Some of the markets for offshoring R&D projects concentrated considerable bargain power on headquarters, as many units fiercely compete for projects. Others were characterized for more benevolent participations of the headquarter or even decentralized demand and supply among units. The behaviour of the internal market for offshore activities in specific divisions of the large multinational companies became the core limitation for success and failure of these activities.

Original Design Manufacturer (ODM)

The model Original Design Manufacturer (*ODM)*[8] configuration, usually associated with ICT companies in East Asia (Hobday 2000; Hobday 1995), has also been found in

[8] An original design manufacturer (ODM) is a company which manufactures a product which ultimately will be branded by another firm for sale.

contract manufacturers (CM) in Brazil. Traditionally, it was assumed by different CMs that the creation of an R&D network overlapping the CM network would result in conflicting interests of their clients. However, the panorama in the industry is changing. Although most multionational CMs traditionally do not have R&D groups, some CM companies are increasing engaging in providing 'design services' for clients.

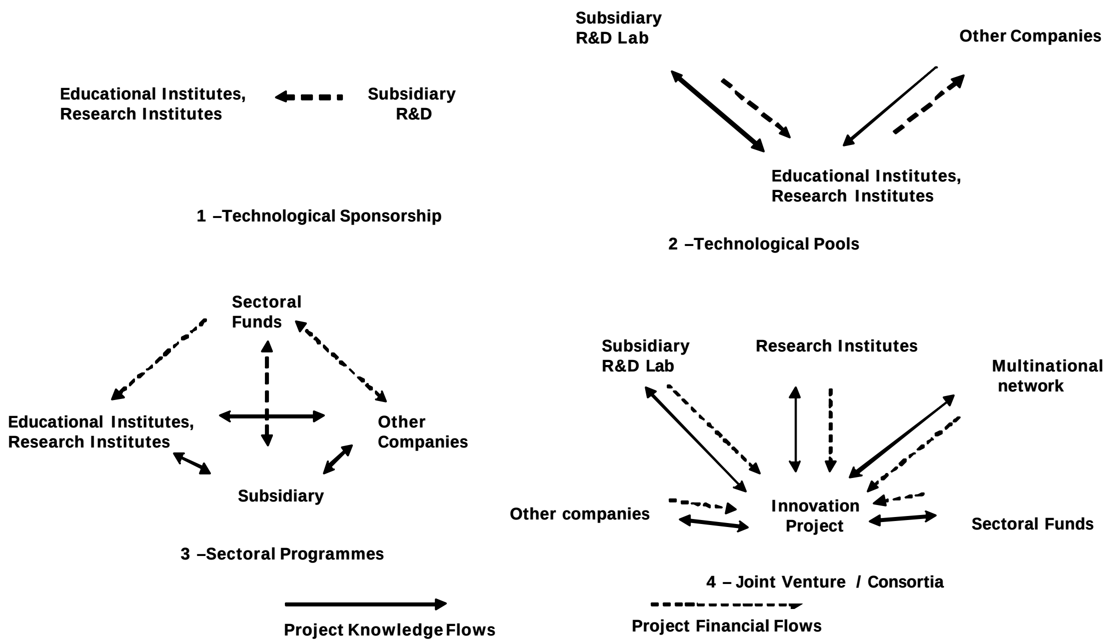
They started to operate in an ODM configuration with the increasing outsourcing of the production activities in the sector. Taking advantage of the tax incentives, some contract manufacturing units offset the costs of R&D to possible clients, providing widespread R&D services to brand owners. Contract manufacturers as Solectron and Flextronics created their own infrastructure to provide R&D services, representing a passage of the second tier multinational suppliers in Brazil following an OEM-ODM path. Contract manufacturers have used the resources to provide product development services for other possible clients, usually other companies with stronger brand and no focus on product development. Generic products such as ATMs, mobile handsets and ADSL modems were developed internally by subsidiaries or in partnership with local partners and then commercialized with the brand of banks, telecom operators and internet providers.

In some cases, these R&D labs in Brazil were among the first inside the global contract manufacturing network. Therefore, in general, the subsidiary activities in innovation tended to be completely stand-alone - especially local product developments - as there were no systematized R&D groups inside the multinational CM. As more and more R&D groups are created inside the CM network, local CMs are also starting to attend ODM global demands.

5.2. EXTERNAL CONFIGURATIONS – INTERACTING WITH THE SECTORAL INNOVATION SYSTEM

External configurations refer to the organizational arrangements where host-country technological institutes such as research institutes, universities and sectoral agencies have a prominent role and funded directly by subsidiaries of multinational companies. These are usually associated with initiatives that aim to develop 'public goods' that would benefit the different actors in the sector. Four usual configurations were observed under this category: sponsorship, resource sharing, structuring programmes and technological consortia. The most common knowledge and monetary flows in these different configurations are summarized in Figure 2 followed by a more detailed discussion.

Figure 2 - External configurations – interacting with the host innovation system



Technological sponsorship

The first simplest configuration identified is Technological *Sponsorship* of local partners, particularly groups in local universities and research institutes. In some cases, subsidiaries offered resources without any substantial expected return, other than a certain level of recognition of the sponsorship. Decisions are based on historical or geographic proximity, social relations or general area of affinity. Although there is usually some sort of result that could be absorbed by the firm at the end of the project, this is usually indirect and accidental (i.e. technical seminars and conferences, new training and disciplines in the local university, research capabilities).

Naturally, different forms of recognition may be expected. However, these are in most of the cases simply a result of the accumulation of specific capabilities in the technological partner or general benefits for the community. In addition, sponsorship allows multinational companies to check affinity and value of partners. Most of the other enabling networks tended to evolve from sponsorship relations between individual companies and technological partners.

In general, however, firms will not be willing to commit large amount of resources on these sponsorship activities. These projects lack economic returns and result in possible benefit to competitors making them sporadic by nature, In some cases, when the creation of teams, laboratories and equipments are sponsored, there might be subsequent problems of economic sustainability given long term fixed costs.

These practices are also important part of the "public relations" of the multinational companies in front of the specialized community. In some technical communities, subsidiary managers face strong techno-nationalism. Indeed, a large number of individuals, groups and organizations had substantial benefits from this type of broad sponsorship to specific projects.

Technological pools

The availability of resources such as qualified engineers, technological services and laboratory facilities and research talent is considered fundamental elements for the dynamic of local and regional innovation systems (Marshall 1891; Powell, Koput & Smith-Doerr 1996). These resources are usually considered a important component for the location of multinational companies (Cantwell & Janne 1999; Cantwell & Iammarino 2003), but these shared resources can also be formed during the interaction with multinational companies.

Some of the relations between multinational companies and technological partners evolved into more stable configurations called here *Technological pools*. In this configuration, the initial allocation of resources resulted in the formation of useful capabilities in technological partners that could be used by the original sponsors as well as other companies. These capabilities developed mainly in terms of infrastructure, training and provision of human resources, services of test equipments and research.

Different actors emerged on the eco-system of technological institutes vis-à-vis established organizations. In many cases, smaller organizations had a larger flexibility to accommodate specific needs of individual companies, such tailored post-graduate programmes and adjustments in the corporate governance of the recent developed infra-structure and personnel, despite their relative disadvantage in terms of technological capabilities.

Relatively small partner saw the possible investments as a clear chance to growth. Institutes such as the Eldorado and Informat developed very fast by partnering with Motorola and Ericsson respectively. As they had a relative small internal organization or they were in a formation period, there was not a strong organization resistance restricting the type of preferential treatment that could be agreed with the sponsor company. In practical terms it meant that the company-institute relationship could be supported by other formal and informal joint-governance mechanisms. In many cases, the original companies had privileged seat on the board of the partner institution (in some cases, even defined in the statute)[9]. Among these new private research institutes, many of them remain highly connected with the original sponsors. For the institutes, this sponsorship was fundamental for their initial growth at the time that it represents a challenge for their diversification. Other companies in the sector did not feel comfortable in entering in partnership with an "institute of a competitor's company".

There were also important differences in the way the sponsor company enforced its influence in the partner. While some institutes had a diversification in the number of clients from the early days, other subsidiaries suffered from changes in the global demand of the main partner and just recently "allowed" the partner to developed more autonomy and share resources with other companies. An extreme example of the unhealthy dependency of the institute with the main client was identified in the CPDIA case, were the closure of the R&D activities in the subsidiary of the Japanese company NEC resulted directly in the insolvency of the institute.

Some pessimist generalizations in recent studies that the MNC's created 'captive' research institutes do not hold for the majority of the multinational companies. Although

[9] In fact, most of these private research institutes have a larger proportion of companies in its administrative board in comparison with other governmental or educational institutions showing that many of them can be well characterised as business associations. More details about their governance in the other trajectories.

these relative new institutes remain highly connected with the original sponsors, the instutes and companies are increasingly networked among themselves. There is a larger level of cross investments among partners in polling together resources and allowing a autonomy of the partner in order to sustain its structure during fluctuations in demand.

Sectoral Programmes

Sectoral Programmes had an important role in structuring and prioritizing initiatives (Tigre & Botelho 2001; Garcia 2002; Stefanuto 2004). Although the leadership of the government varied over time, new institutional mechanisms emerged during the period in order to strengthening these forms of collaboration. From the beginning, some subsidiaries were openly involved in the support of government-led structuring programmes. Programmes such as the National Research Network (RNP), were in fact mostly sponsored by individual companies. Others, such as the Softex - initiative - that aimed to promote the exports in software - did not manage to attract the expected investments from individual subsidiaries. In part, subsidiaries started to reallocate resources to other priorities shifting away from the government agenda. For, instance, multinational companies had little direct interest in promoting domestic firms' software exports programme.

The initial different programmes had an important role in creating linkages between individuals in different organizations and formed the basis for some other forms of governance structured in the sector in 2003. The initial scheme based on voluntary funding from companies was substituted by compulsory contributions to a sectoral fund. Changes in the legislation created new sectoral fund based on compulsory contributions.

More recently, the redistribution of these funds was organized in terms of public calls for projects, supporting initiatives in terms infrastructure improvement, training and research.

There are though further conflicts in relation to the politics on the governance of sectoral resources. The process of selection at sectoral level may not necessary represent the wishes of the companies that contribute to the sectoral fund. (In fact, interviewees argued that there was a general bias against supporting companies already receiving the existing benefits). In general, the selection process tended to resemble the decision-making process in research bids, therefore academic excellence of the proponents tend to be more important than structural sectoral relevance.

Technological Consortia

Different forms of technological consortia have been proved important in sectoral systems around the world (Ernst 1998; Amsden & Chu 2003). In Brazil, different organizations, particularly private research institutes, emerged as key node of integration of new technologies and products. These organizations operate in a complex and dynamic environment, forging associations between government, universities, small and multinational companies. After strong investments in organizational development involving improvements in professional certification and quality standards, different associations and private research institutes developed increasing autonomy for developing their internal projects.

For instance, FITEC (which had at some point a almost exclusive partnership with Lucent, diversified to 12 different market segments (e.g. financial, commercial automation, electro electronics, energy, manufacturing, medical, sanitation, telecom suppliers and operators, IT and e-government). It has used its surplus to create its own research lines (e.g. UAV, VoIP, Auto-fit-metering and city-survey-palm tops). In 2005, the institute had their products in areas such as medical automation, power line transmission and non-manned airplanes. Although in some cases, the institute ventured in developing their own series of products, in some cases, the institute has shared investments and intellectual property with different partners. In 2005, just one third of their projects are related to the IT Law and 40% of the projects are inside the partnership with Lucent.

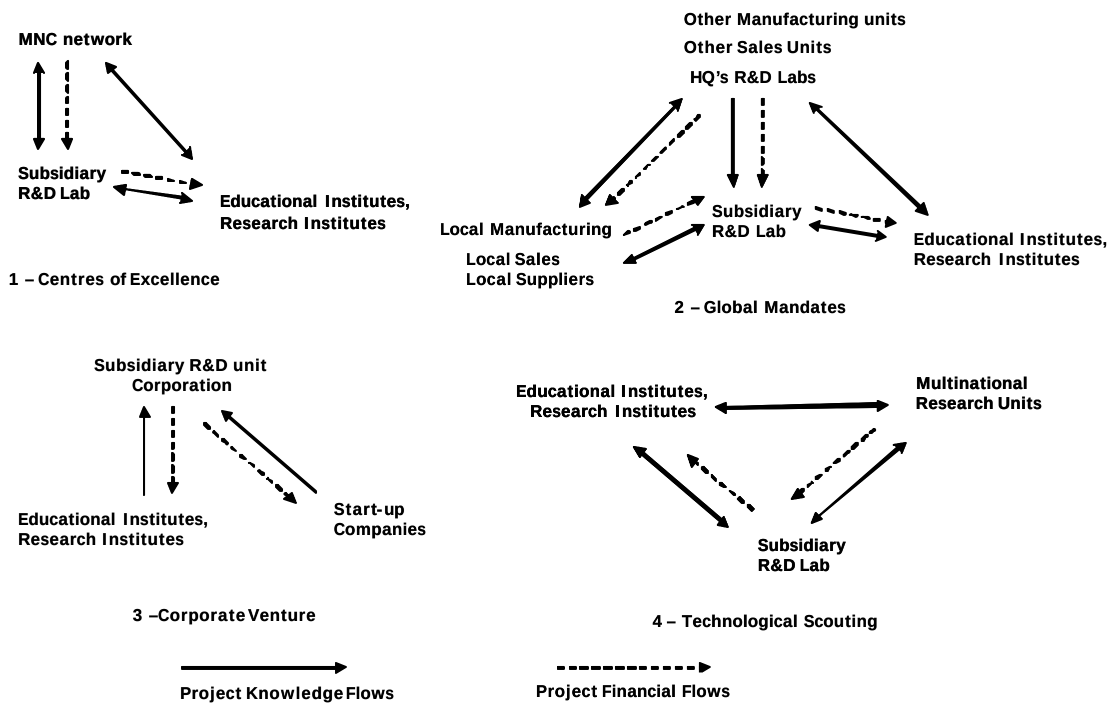
The migration from a project-based organization (where services in product and process development are commercialized by hour), to a joint-venture model (where investments are shared and outcomes are co-owned) represents an important shift as the latter can provide sustainable sources of income, and therefore autonomy on future investments.

There are still many institutes highly dependent on the specific partners and in the incentives defined inside the regulation. Certainly in the short-run, the existing framework derived from tax obligations provided them with a steady source of income. However, an abrupt change in the regulation is a horrifying prospect for different institutes. In addition, these investments are risky for organizations that operate in strict project-by-project budgets and many of their core partners, including mainly MNCs, are very reluctant in relation to any shared property rights. Despite all the difficulties, different form of consortia and joint-ventures between non-profit and commercial organizations are emerging provide a way to diversify and promote a deeper integration of the technology into the sectoral structure.

5.3. INTEGRATED CONFIGURATIONS – GOVERNANCE IN COMPLEX SYSTEMS

Finally, there were a set of configurations that involved a stronger coordination among actors. Figure 3 shows group of configurations identified: corporate venture, center of excellence, global mandates and technological scouting.

Figure 3 – Key configurations inside the developed networks.



Corporate Venture

Corporate Ventures are important part of the way companies attempt to manage disruptive technologies in high-tech industries (Bygrave 2004; Ferrary 2003; von Burg & Kenney 2000; J. Tidd & Taurins 1999; Sahlman 1990; Florida & Kenney 1988). However, little is know about corporate ventures of multinational companies in developing countries like Brazil (Hobday & Perini 2006). The exploratory study showed that indeed some subsidiaries developed corporate venture funds financing disperse groups and promoted projects with academics and entrepreneurs.

Some subsidiaries refined complex procedures to receive proposals from academics and entrepreneurs and analyse them according to different internal needs. Some subsidiaries could receive up to 30 projects every month from established and new partners. A reasonable amount of projects were business ideas of independent entrepreneurs. After receiving seed money, they created a number of new products in universities and even independent companies in areas where they found relevant interests. Direct results from the project were intertwined with indirect benefits such as start-ups developing games for mobile phones to companies that could become future clients in manufacturing.

However, the funding of new independent groups still tended to be a very small part when compared to finance of projects led by private research institutes. A important stream of new ideas for projects started to be presented to subsidiaries by partners that already understood specific core technologies and even the “look and fell” of the subsidiary products.

The formation of new companies also happened when groups working for the R&D labs eventually run out of relevant projects from the original partner. Different groups started to pursuit their own initiatives. Some of these new companies made use of other forms of support in organizations such as business incubators and venture capital (that in Brazil was still very scarce and mostly provided by the government), and some of them became important new national companies.

Centers of Excellence

Although developing countries are usually assumed to be unusual places for Centres of Excellence inside the MNC (Chiesa 1995; Holm & Pedersen 2000), many subsidiaries have disputed and obtained differentiated status inside the multinational network. Most of the capabilities developed came from successful integration and differentiation inside the multinational knowledge network and the development of a local "eco-system" of technological partners. Brazilian differentiated themselves into centers of excellence in specific technologies or components, avoiding direct competition with other em(J. Birkinshaw 1996; Andersson 2003)erging R&D units (especially in India and China).

The recognition as Centers of Excellence for specific technologies and products has important advantages. In most cases, the integration of the R&D activities resulted in the formation of matrix structures were local project managers respond directly to R&D units at the headquarters and negotiate resources with specialized teams of different local divisions. Most of the interviewed R&D managers consider their direct superior in the HQ labs rather than in the local subsidiary. For the subsidiary, entering inside the global R&D structure was the key to maintain their R&D teams despite the oscillations in the local market (and therefore regulated R&D expenditures). By accessing, using and developing core technological capabilities company-wide, the subsidiary could profit form a stable income connected with corporate demands. Large R&D groups in the subsidiaries survived and thrived inside the corporation network. Northern has a Competence Centre in Mobile Technology since 1998 (150 engineers in R&D). Motorola Brazil has almost half of its 500 engineers in R&D in a group responsible for worldwide Messaging software for all the company's handsets. Lucent Brazil has shifted its investments more and more to software in new areas such as optics and mobile and Siemens Mercosur in Curitiba (200 employees in R&D) is among the top 5 R&D centers in mobile technologies.

This global integration is also associated with some disadvantages. First, unsurprisingly, this increasing integration resulted in a decreasing autonomy. At the end, as discussed in the system trajectory, global project managers are responsible to allocate the projects that will be conducted in each location, and the units become more and more dependent of these assignments to maintain the existing groups. Consequently, it can reduce the ability of the subsidiary in identifying and react to technological discontinuities becoming vulnerable to changes in the product technology.

Entering into the MNC funding structure sheltered large local R&D units against the volatilities of the internal market. The sustainability however depends of a constant identification of project opportunities inside the MNC and a project to project development of trust, quality and creativity. The bargain power of the headquarters is vast in some structures and the global downturns and upturns become very important to the local units.

Centers of Excellence were not perceived as stable positions. Indeed, the global project managers could induce inverse knowledge flows among different units. For instance, in the case of Dell's subsidiary, the unit was the first off-shoring unit inside the multinational company. They developed new processes required for professional off-shoring, as it was not systematized inside the corporation. Recently, they were responsible for transferring many of these processes to other units in India and Russia (in principle, their "direct competitors").

A simple matrix structure is not adequate to describe the organization of some of the most diverse multinational companies. In some cases, companies provided services to a large number of internal divisions. Motorola Brazil, for instance, became responsible for the testing of all new corporate handsets by integrating capabilities developed in hardware, system and software in different moments and projects. HP in Brazil, after supporting many internal divisions, differentiated itself so much from other units that become directly connected with the corporate labs (the HP Labs) giving its capability as system integration in a wide range of products. The subsidiary in Brazil differentiated itself from labs in India and China that are responsible for technologies for developing countries, the labs in Brazil are connect with leading edge corporate research. This requires building a network of partners that would sustain this differentiated position inside the corporation. However, considering the limitations in the local dynamism when comparing to main global centers, it is possible that the life-span of these centers of excellence in developing countries tend to be shorter than their counterparts in developed countries.

Global Mandates

Some subsidiaries developed *global mandates* in specific products inside the industrial corporation (J. Birkinshaw 1996). These mandates were usually result of historical competences available in the acquired companies that used the established complementary capabilities in the multinational to expand the traditional products. For instance, Lucent has entered the Brazilian market through the acquisition of two main national telecom companies, Zetax and Batik, in June 1999. The acquired companies were specialized in small PABX (switchers with low number of access points - ZTX-610 and Elcom), a product not available inside Lucent at the time. The Brazilian lab transformed the previously local products in global ones, therefore, responsible for the BZ5000 that was sold worldwide through Lucent's distribution channels. In 2005, there were no sales of the product in Brazil anymore; the subsidiary remained responsible for 100% of the improvements on this product sold mainly in Asia. The subsidiary combined successfully the competences acquired in the national companies and the linkages within the international group, using the "best of the two worlds". However, the product suffered a discontinuity worldwide. The product became mature and the next generation of the small PABX inside Lucent would be based on a company recently acquired by Lucent in California. The lost of the worldwide responsibility for the small switchers was especially disappointing for the subsidiary. The next generation of this product could become one of the leading products inside Lucent worldwide.

This example shows the opportunities complexity of sustaining global products inside the MNC network. Developing global products allows subsidiaries to explore the global channel of distribution and sustain large teams and networks of global and local suppliers of technology. This usually requires a close connection with leading users too and this is usually the key limitation of this configuration for subsidiaries in developing countries. There were some cases were local products developed by subsidiaries to attend specific needs of the rural areas managed to be converted into global products One of the most successful projects developed for the local market, and then sold abroad, was the

DLU/Shelter, a self-sustained switcher for remote rural/ less-populated areas adapted to the disperse population in the Brazilian territory. The product, initially developed to the Brazilian market, became worldwide product sold by Siemens subsidiaries especially in developing countries. Other trend is the development of local products to global players. Some products developed by the subsidiary of Motorola to global telecom clients were very successful, and, therefore they were transformed into a global demand to the global client. The global client had then contacted directly the subsidiary in Brazil, creating tension in the internal attribution of markets. At the moment, however, the relative position of the region in the global trade means that this configuration remains an exception.

Technological scouting

Finally, *technological scouting* (Joe Tidd & Trewhella 1997) was pursuit by a number of subsidiaries. This final configuration is especially surprising in a developing country. Some multinational companies have ventured resources to the development of eco-system of relationships with universities and research institutes where they could promote the research groups aligned with multinational corporative needs. This alignment would influence in the formation of human resources in universities as well as the improvement of general infra-structure and technological services provided.

In addition, pursuing an alignment between local and global networks, the subsidiary intended to be able to explore earlier new product development opportunities emerging in the multinational. Hence, in addition to the contribution to the MNC as a whole, the subsidiary aims to improve its own competitive edge in relation to other locations.

This naturally brings questions marks related to how MNCs absorb the research developed in the Brazilian universities. Given the co-evolving nature of the capabilities and opportunities, it is sometimes difficult to determine whether these activities could be characterized as developing or draining local capabilities. Would the leadership of multinational companies configure an early brain drain of local skills and ideas and perpetuate dependency? Or would it be a small price to pay to get involved in these global research networks?

This is obviously subject to considerable controversy. Indeed, different interest groups started to organize themselves in associations in an attempt to define a general rule in relation to intellectual property rights. However, there are fears that this will lead to additional rigidities and would easily hamper investments in more promising technologies. In principle, a more productive answer would involve expanding the number of organizations interested in talents developed in the region and therefore creating more cross-fertilization between interests of MNCs and other actors in the sector. Rather than regulation, a dynamic demand from companies and different forms of risk and investments shared among stakeholders seems to be the preferable solution among different stakeholders.

6. Debate and conclusions

This paper applies a project-level analysis to explore the dynamic and multi-level process of organization of innovation around R&D laboratories in subsidiaries of multinational companies. Twelve different configurations between innovative activities in multinational companies and the host country innovation system were identified. These recurring configurations identified were represented in Figure 1, 2 and 3 and their general characteristics were discussed in section 5. The relationship between different groups of stakeholders and different configurations is summarized Table 3.

Table 3– Main aims of the innovation projects in usual configurations

		Multinational network	**Subsidiary (marketing, manufacturing)**	**R&D Laboratory**	**direct technological partners**	**other non-regulated companies/ organizations**
Internal configurations	**Local Products/Processes**	Risk of excessive diversification and increasing coordination costs	Economic benefits from new/improved products and process (economic risk of failure)	**Capacity building, Technological and market links**	Capacity building / Income from R&D services (3)	Increased competition and better products in local markets.
	Audit and certifications	New suppliers in the internal market	Improved systems	Capacity and reputation building	Capacity building (3)	
	Offshoring R&D	**Reduced cost of R&D activities**		**Participation in global R&D network/ sustainability of investments**	Capacity building / Income from outsourced R&D services (3)	
	Original Design Manufacturer	New services for global clients	New services for CM clients (4)	**Sustainability of investments**	Capacity building / Income from outsourced R&D services (3)	Collaboration with local brand leaders
External configurations	**Technolgical Sponsorship**		Public image/ reputation	Identification of talent / reputation	**Capacity building**	Possible direct benefits
	Technological Pools			Supplier development	**Capacity building**	Use of new supplier (2)
	Sectoral programmes			Outputs of sectoral projects (1)	Outputs of sectoral projects (1)	**Implementation of sectoral agenda**
	Technological Consortia	Possible new technologies and products (Worries about technology leakage)	Possible new technologies and products (Worries about technology leakage)	**Shared risks and investments**	**Shared Investment and reputation**	**Shared risks and investments**
Integrated	**Global Mandates**	**Diversification, particularly in relation to appropriate products to DC**	**Economic benefits from global products and process**	**Core nodes in the global chain**	**Advanced technology and increasing relevance in the global value chain**	Increasing connection with external markets

	Multinational network	Subsidiary (marketing, manufacturing)	R&D Laboratory	direct technological partners	other non-regulated companies/ organizations
Centers of Excellence	**Incorporation of new core competences into the MNC**	**Increased understanding of global markets**	**Economic Sustainability of R&D activities and leadership status**	Economic Sustainability	Dynamism and technological leadership of local organizations
Venture Capital	Possible new products	**Possible new product lines**	Complementary competences	**Shared Investment and reputation building**	New high-tech start-ups
Technological Scouting	**Ideas /Talent scouting**	Talent identification	Differentiation of Capabilities/ earlier entrance in product life-cycle	**Participation in MNC R&D network/ Research outputs (2)**	Indirect benefits on educational/research system (2)

1. Depending on the priorities of programmes (may not incorporate interests)
2. Depending on property rights rules defined by company
3. When activities are outsourced to local partner
4. Mainly in contract manufacturing companies

The different shaded cells represent the core actors (dark grey) and participating actors (light grey) in different configurations. The table is useful to establish some general benefits obtained by different actors when engaged in specific configurations.

The results presented here are in a larger context compatible with some previous classifications of R&D roles. For instance, configurations focusing on external and internal networks are similar to asset augmenting and asset exploiting R&D units respectively. However, the approach adopted here allows the deeper exploration of a wider number of configurations than usually attributed to R&D subsidiaries. This approach coincides with Kogut's position that simplified typologies of the expected role of subsidiaries provided by the international management literature have done little to advance our understanding about the process by which subsidiaries evolve (Kogut 2002). A detailed description of the usual underlying combination of structure and strategy in R&D activities provide more interesting insights in this respect. Mapping the common knowledge and monetary flows in each configuration allowed distinguishing how different groups of stakeholders benefit from individual projects and the complexity required for developing complex governance structures. The detailed exploration of the show that different observed organizational configurations allowed discussing the sustainability and stability of these configurations.

There are a number of implications derived from the research:

Innovation projects provide an important mechanism for the transmission of codified and tacit knowledge. The most recent considerations point to the concept that specific inter-organizational mechanisms are necessary to allow local firms and institutions to acquire knowledge created in the multinational knowledge network. However, they are not enough. There is also, a need to align interests of the specialized communities developed among subsidiaries, different units of the multinational companies and different external sources are crucial for possible flows of knowledge. Although it has been acknowledge that the advances in ICTs facilitate the codification of knowledge and lower the cost of exchanging information between distant nodes of the MNC network, codified information does not preclude the requirement of firms to be deeply engaged with local tacit and social network. Most significant types of learning will just occur where social communities make intentional use of their relational structure and shared coding schemes to enhance the transfer and communication of new skills and capabilities (Kogut 2002; Kogut & U. Zander 2003; U. Zander & Kogut 1995). Innovation projects provide an important organizational structure for the development of these shared schemes inside and among organizations.

The knowledge flows between the multinational and national networks are contingent upon the underlying organizational configurations in innovation projects. Although, R&D laboratories in subsidiaries are usually assumed to be key elements in promoting the flow of knowledge between the multinational sources of technology and the local industry, most of the activities tend to be organized around configurations that engage separately national technological partners, different subsidiary functions and players in the multinational company. This supports the idea, that the subsidiary contains internal isolation mechanisms (Sölvell & I. Zander 1998) that needs to be acknowledge. In a number of cases, interorganizational linkages with both national and international partners do exist, but they are composed of different groups of people specialize in attending different demands. In other cases, R&D departments may develop strong international linkages and, at the same time, have no connections even with other departments inside the subsidiary. Even when both organizational linkages exist, subsidiaries can also use internal mechanisms to passively or actively deter knowledge from flowing through different networks. At the same time, the study shows that there are a number of complex configurations that interconnect national and international knowledge network. It points to the increasing importance of understanding the objectives of different actors and different forms of governance mechanism that would allow the identification and pursuit of complementary aims.

The subsidiaries knowledge network is formed by superposed project-based configurations. The examination of the different configurations shows that subsidiary development is not a linear process of accumulation of technological capabilities. Achieving more complex configurations seems to be a result of historical combinations between configurations over time. Non-linear attempts in unusual innovation projects introduce crucial opportunities to the long term development of the subsidiaries even when they are small in size when compared to projects in established configurations. Subsidiaries test different organizational characteristics in specific innovation projects, usually related with an entrepreneurial action occurring at non-particular time. Depending on successful performance perceived by stakeholders and general context, these individual projects may evolve into relatively stable patterns of relationships and superposed to previous configurations forming more complex organizations. Experimentation with different configurations seems to be a necessary condition as each one of the different configurations has their own challenges for achieving sustainability over time. The concept of punctuated equilibrium (Romanelli & Tushman 1994; Van de Ven & Poole 1995; Egelhoff 1999) seems to be an important element to be investigated in the subsidiary development.

The knowledge flows (and their direction) depend on the alignment of interests among stakeholders. The analysis of the motivations, aims and benefits of different stakeholders in engaging in a large variety of collaborative activities helps to shed some light into the knowledge flows occur between multinational companies and host innovation systems. The literature on multinational companies and developing countries has usually assumed that knowledge would spill over from the multinational to the host country innovation system. This is not necessarily the case. In most of the configurations, there are variations in informal and contractual rules that influence the way knowledge may flow among partners. They range from participation on boards, contract requirements in terms of intellectual property, These variations, usually result of evolving negotiation of interests and evolving practices among the different parts that are a crucial determinant of possible knowledge flows and their direction. More than simply a recognition of specific role in the multinational heterarchy, issues of interactive learning and dynamic evolution through the interaction with the multinational network and host innovation system became essential in determining the direction and magnitude of the knowledge flows.

The direction of the knowledge flows depends on the organizational learning occurring after the end of innovation projects. Very few configurations would have widespread benefits to a wide number of actors. Most of the knowledge created in projects has specific aims that are defined inside the scope of the project. The knowledge created in specific projects may be codified and transferred to subsequent projects and become part of the organizational and inter-organizational learning (Nonaka & Takeuchi 1995). Other important part of the knowledge is embedded in the specialized community in the form of tacit knowledge (Sapsed et al. 2002; Sydow & Staber 2002). The ability of different organizations to incorporate this tacit knowledge after projects are concluded and teams are disbanded is a crucial determinant of the long-term direction of the knowledge flows in the sector. Indeed, it may be that the knowledge flows to other partners do not occur when the organizational linkages existed. When specific configurations fail, there was a need to reorganization of existing capabilities to new situations. Naturally, this is not to say that failures in intra or inter organizational linkages were beneficial to the knowledge network. Successful innovation system has considerably stable accumulation of technological capabilities, rather then very strong "creative destruction" (Cantwell 2001). In general, the result of dismantling of a highly differentiated group is significantly dysfunctional given the tacitness of the activities involved. To create a group that operates efficiently in a sustainable configuration involves considerable resources, strategic vision and time. Most of these transitions between different configurations involves a significant level of uncertainty and may face considerable inertia from groups of stakeholders. The ability of different organizations and the community of practice to adapt and learn beyond different projects should be considered an important determinant of the direction of the knowledge flows in sectors.

This exploratory taxonomy of the configurations between multinational companies and sectoral innovation systems in a specific sector and historical context still faces a number of limitations. At the same time, most of the configurations identified here are not new in the literature and most of them have extensive documentation in both international management and organization of innovation literature. The contribution of this research is the attempt to provide a project-level comparative framework for the analysis of the organization of innovation that should be validated, adapted and expanded in different sectors and contexts. Combination with quantitative approaches examining into the structure of the interaction in innovation projects would also be important to unravel and validate the role of different configurations the diffusion of knowledge in sectors.

Finally, this research has also implications for decision makers in different instances. Clearly, regulation may support higher investments in R&D, but it does not necessarily enforce a project portfolio that promotes local and global knowledge flow. The advantages and disadvantages of different configurations reinforce the fact that prosperous knowledge networks in sectors need a multitude of governance formats and coordination mechanisms among multinational and national companies, government and universities and research institutes. Rather than general best practices, the contributions from individual actors will depend on the specific position of individual actors and stage of development of the sectoral knowledge network. The complex alignment between global and local networks happens project by project.

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Annex 1 – Sample of projects conducted by selected subsidiaries between 1997-2003

Company	Some Innovation Projects
Celestica	Capacity Building - Training, Productive Process Development, Introduction of New Products, Quality System Maintenance, Metrology, PCMM – Professional Certification
Dell	R&D Centre in E-Business, Priority Programmes, Internal System Development-SYNCHRO, Software Factory, R&D Management System, Global R&D Management Tools, Productive Process Development Programme, Software Development Management Centre Programme , Direct Order Management system (DOMS)
Ericsson	R&D centre in Wireless Communication through mobile phones, Applied Product Development - Wired Network, Environment for Operational Courses and Training Development, Frame Relay, Integrated SAP Projects, General Product Development Programme, R&D Programme in CDMA, R&D Programme - Commutation Systems, Data Communication Networks – Development unit
Furukawa	Optical Cable Development, Network Management Integration system, New Families of Optical Cable, System Projects Development, Solution Development for Multiservice Networks , Research on Coaxial Fiber hybrid system development
Hewlett Packard	Diagnostics, Manageability, Software Installation and Configuration, Jet cap, Linux Kernel, OpenBank Architecture, Supportability, TopTools Project
LG	Plasma Monitor 42", LCD Monitor 30", Laboratory Expansion – Public Researcher Antenna, Multimedia Educational Software Applications , R&D Lab Upgrade , Productive Process Environment , Total Quality System, Web Terminal
Lucent	BZ Spack Application, R&D Lab in Data Treatment and Transmission , Information System Development, Phone Centre Evolution BZ5000, Technological Partner Implementation and Operacionalization Programme, MPEX Project, S-PACK Project, New services ofr Wireless Systems and Internet Access, SDP / GAF
Motorola	Integrated Circuits, Wireless Telecommunication Terminals, K-Java, National Training Programme – University Curricula Development, Product Design Center, Organizational Quality System, SW Centre
Northern Telecom	Mobile Phone Software Development , Lab Implementation , Certification and Homologation Programme , NSM Programme, TDMA-Access Programme, Radio Frequency Engineering Server , CDMA Network Management System
Siemens ltda	Hardware Laboratory, Handset Phone, TNMS, Electronic Digital Switching System, H300, Corporate Quality System, Central Access Card, Transport System

Solectron	Scientific Collaboration agreements, Electronic Boards Manufacturing Process , Computational Models Knowledge Library , Business Intelligence (BI) - CPQD, IT Project Management, Open Software and Bank Automation, Laboratory Expansion – Public Researcher Antenna, TI and Software Development Program, ATM Electronic Equipment ,