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**R&D ROLES IN SUBSIDIARIES OF MULTINATIONAL COMPANIES:
WHEN DOES THE INSTITUTIONAL ENVIRONMENT MATTER?**

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This study examines the factors that explain the roles of foreign R&D units in subsidiaries of Multinational Companies. The paper proposes a typology of R&D roles in foreign subsidiaries of MNCs derived from a conceptual framework based on three elements: (1) R&D partnerships, (2) governance modes of global R&D activities and (3) the institutional environment of the host country. While previous research suggests that global R&D roles in foreign subsidiaries are associated with strong R&D partnerships, this paper argues that subsidiaries with a weak or non-existent network of R&D partnerships may also gain global R&D roles. This may happen when the host country institutional environment provides cost incentives and if there is competition among the R&D units of the MNC. Our arguments will be illustrated using examples from Brazilian R&D units. The study suggests that organisational studies alone cannot sufficiently explain R&D roles and need to be complemented with an approach drawing on institutional economics.

Keywords: Multinational Companies, R&D roles.

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1. Introduction

In the past, multinational companies (MNC) set up R&D units in newly industrialising countries (NICs) in response to two major drivers, Science and Technology Policy and MNC headquarters' competitive strategy. Some NICs were actively promoting local R&D activities at least two decades before market liberalisation took place in the 1990s. Their main S&T policy instruments included incentives or subsidies, different kinds of trade barriers and country-specific technical standards. In some industries, former purchasing policies of state-owned companies required foreign owned equipment providers to establish production and R&D units. In order to rapidly increase market shares, several foreign-owned MNC subsidiaries opted for developing local products different from those of their mother company. In addition, lower purchasing power, climatic and geographical conditions as well as different modes of usage of technology forced subsidiaries to develop cheaper product variants with technological properties quite distinct from their originals. These and other factors resulted in two generic types of foreign technological activities, adaptive engineering and local original product development.

The 1990s challenged this situation due to the crises of development models based on import substitution, global trade liberalisation and the rapid advance of a new wave of industrial innovation driven by telecommunications, digital network, software and Internet technologies. This phase of globalisation has been accompanied by the proliferation of global technological standards in many industries, global product policies as well as an avalanche of mergers and acquisitions. The latter has resulted in duplications of R&D infra-structure in MNCs and high coordination costs.

In order to increase overall R&D efficiency, many MNCs have been initiating a worldwide selection process among their R&D units. MNCs face choices such as maintaining or reducing the local R&D activities of their subsidiaries as well as upgrading, giving foreign subsidiaries global responsibilities in R&D. The objective of this paper is to explain why some foreign R&D units are limited to local roles while others are entitled to assume global roles.

Previous research has shown that MNC subsidiaries maintaining strong and durable relationships with host country partner organisations, such as suppliers, key clients or research institutes, are likely to build up technological capabilities, to generate innovations, to increase

	Product development for global markets	Product development for the local market
High importance of external R&D partnerships	Type I	Type II
Low importance of external R&D partnerships	Type III	Type IV

Figure 1: Typology of R&D roles in foreign MNC subsidiaries

market performance and to contribute to corporate R&D projects. In particular, relationships with host country partners are likely to increase the chances of the R&D unit to host a centre of excellence (Andersson, Forsgren 2000; Frost, Birkinshaw, Ensign 2002). This relationship corresponds to "Type I" and its counterpart, "Type IV" in Figure 1.

However, this view seems to ignore alternative relationships between the following two variables, (1) the role of foreign based R&D

units in corporate R&D and (2) the links between R&D units and their external partners. We argue that R&D units can, under certain environmental conditions, develop global products or contribute to global R&D projects even if their relationships with external partners are weak

or non-existent; this is a distinct contribution to subsidiary role literature and is represented by “Type III” in Figure 1. In addition, we explain why R&D units with strong host country relationships can be held back in development for global markets (“Type II”). Thus, this paper attempts to provide an integrated approach: a typology which explains all four types of R&D roles.

Behind the typology, there is a theoretical research question: what does the location of more advanced R&D roles influence – institutional economic drivers or organisational power? Economic drivers refer to cost and efficiency differentials and organisational power has to do with intra-organisational relationships, such as resource control, hierarchy and ‘political behaviour’, among others. We argue that both economic and organisational power considerations are indispensable to explain R&D roles. This might seem obvious at first glance; however, we identified types of R&D units which are predominantly driven either by cost or by organisational power.

The paper is structured as follows: section 2 sets out the main elements of our conceptual framework which seeks to explain all four types of R&D roles. On this basis, section 3 discusses different combinations of the framework elements and formalizes them by theoretical propositions. Each proposition is illustrated using anecdotal evidence. The discussion and conclusions (section 4) put forward some theoretical implications as well as suggestions for future research.

2. Conceptual Framework

The attribution of R&D roles to foreign R&D units can be understood as an outcome of organisational power based on resource dependence (Doz and Prahalad, 1991). As headquarters generally control MNC resources, it is obvious that they exert power over their subsidiaries. Conversely, subsidiaries may build up a power base despite their subordinate hierarchical position as long as they manage to control critical resources (Ghoshal, Bartlett 1990; Forsgren, Pedersen, Foss 1999; Andersson, Forsgren, Holm, 2002). In contrast to economic reasoning, outcomes of power relationships are not necessarily rational from an overall MNC perspective, while they may be positive in the interest of an individual MNC unit – invoking Allison (1969, p. 711), “*where you stand depends on where you sit*”.

Mainstream economics, in contrast, would suppose that organisational decisions about the attribution of R&D roles are rational from an overall MNC perspective, the main drivers of MNC decisions being costs and efficiency differentials. Economic theory has made several contributions regarding R&D globalisation (for instance, Buckley, Casson 1976; Cantwell, 1989), though less so on R&D roles. According to Buckley and Casson (1976, p. 53), “in the absence of communication costs all R and D activities would be located where non-tradable inputs, notably skilled labour, were cheapest”. Nearly thirty years after the first edition of that seminal work, communication costs have dramatically shrunk and skilled, low cost labour is increasingly available in developing countries. Hence, we would expect that R&D roles will be assigned to those R&D units, which permit maximising R&D outputs while minimizing R&D costs. Of course, other economic considerations¹ may also guide the assignment of R&D roles, however, their empirical relevance has been put into doubt (Cantwell, 1995) and the increasing possibilities to work in globally spread virtual R&D teams could eventually reduce the importance of scale economies and agglomeration factors.

This study intends to capture these theoretical concepts in a way compatible with previous research streams. As for organisational drivers, the power balance among different MNC units is considered as an outcome of different combinations of two framework

¹ See, for example, Pearce (1994), Caves (1996) on such as economies of scale and agglomeration.

elements: “R&D partnerships” (see subsection 2.2) and “governance of global R&D activities” (see subsection 2.3). Economic drivers result from a particular combination of the framework elements “economic environment and relative costs” (see subsection 2.4) and “governance of global R&D activities”. The following subs-sections introduce each of these four elements separately; later on, they will be linked together and illustrated by anecdotal examples (section 3).

2.1 Local vs. Global R&D

R&D globalisation has repeatedly been considered a myth (Patel and Pavitt, 1992). While overseas investments in R&D have risen over the past decades, innovative R&D activities still remain concentrated in their home countries; correspondingly, technology trade flows from parent firms to their foreign subsidiaries remain strong (Doremus, Keller, Pauly, Reich, 1998). Thus we would expect that subsidiaries concentrate on local product adaptation or local original R&D and very rarely contribute to the development of global products, particularly, when they are located in peripheral countries.

Adaptive engineering means that existing technological specifications are reproduced or improved in order to better match local demand or local production conditions. Local original R&D implies the development of new products for the local market. Yet, even product development and research capabilities do not automatically imply a global R&D role within the MNC (Birkinshaw and Hood, 1998): it is necessary to consider decisions made by headquarters or subsidiary management as well as the impact of the host country environment on these decisions.

We know that many different roles of R&D units have been identified², however, there is reason to believe that the real divide is between local and global R&D. Hence, we focus on two extreme roles of off-shore R&D units: local and global R&D. Local roles include activities from product adaptation to local original R&D. Global roles imply the contribution to global R&D programmes or the development (production and export) of entire products for world markets.

While global contributor roles cover design centres, centres of competence or excellence, the development of entire products for world markets are sometimes called ‘global subsidiary mandates’ (Roth and Morrison, 1992) or ‘world mandates’ (Feinberg, 2000). A global subsidiary mandate implies that worldwide strategy and coordination of all value chain activities (R&D, production, logistics, and marketing) are concentrated on one subsidiary. ‘Centres of excellence’ in R&D take part in global projects, often coordinated by headquarters, because of their distinctive knowledge and leading technological capabilities within the MNC. Note, though, that the technological scope of centres of excellence can be quite narrow due to increasing technological and scientific specialisation.

2.2 The importance of R&D partnerships

As the stock of knowledge increases exponentially, only very few companies are able to develop new technology using exclusively knowledge accumulated in-house. Innovation becomes more and more systemic and complex (Chiesa, 1995). As a consequence, different components and scientific or engineering disciplines need to be integrated in one product. Since organisations are generally not self-sufficient (Pfeffer, Salancik, 1978), organisations need to source complementary knowledge by means of R&D partnerships.

These “partnerships are defined as cooperative arrangements engaging companies, universities, government agencies and laboratories in various combinations to pool resources

² See, for instance, Gupta and Govindarajan (1991); Chiesa (1995); Nobel and Birkinshaw (1998).

in pursuit of a shared R&D objective” (Hagedoorn, Link, Vonortas 2000). As von Hippel (1988) pointed out, suppliers, users and competitors may constitute important sources of innovations. Conjoint R&D, co-development or simultaneous engineering together with suppliers, facilitates integrating technologies from different sources. R&D partnerships are also a vehicle in order to have access to new knowledge and laboratory equipment. University institutes, for instance, can carry out risky and time consuming basic or applied research in order to explore new technological opportunities as well as technological services such as prototype building and testing, certification, information services laboratory analyses and consultancy services, among others.

Different from arms’ length market relationships, R&D partnerships may result in learning opportunities and inputs from partners are likely to influence the subsidiary’s product designs. Reciprocal exchange of knowledge can create mutual interdependencies among several organisations and facilitate long-term relationships. When a particular subsidiary obtains access to valuable external R&D resources, the relative distribution of R&D resources within the MNC can change. Consequently, a subsidiary would be in a better position to become eligible for global R&D. However, R&D partnerships in host countries do not necessarily entail global R&D roles, which can be explained by corporate factors.

2.3 Governance of Global R&D Activities

This element of our conceptual framework deals with the set of relationships among different R&D units and headquarters, sometimes called internal network³. Governance, a term borrowed from institutional economics, refers here to the coordination of MNC R&D units localised in different countries, concerning, in particular, global R&D project allocation. Yet, different from Williamson’s (1991) three forms of governance, hierarchy, hybrid and market, our concept of governance of global R&D activities takes into account both cost-efficiency reasoning and the existing R&D resource distribution within the MNC. Thus it is compatible both with economic and with organisational drivers. Since organisational power is tied to resource distribution, the governance mode depends on how critical R&D resources such as laboratory equipment or sticky knowledge are allocated throughout the MNC: they can be centralised or decentralised, duplicated or non-duplicated. Consequently, three generic governance modes can be distinguished: (1) under the centralised governance mode, the overwhelming majority of R&D resources is concentrated (and non-duplicated) at headquarters. (2) Under the decentralised cooperative governance mode, R&D resources are spread over several R&D units without significant duplication. (3) Under the decentralised competitive governance mode of R&D activities, R&D resources are duplicated and distributed over several R&D units.

(1) The centralised governance mode implies that knowledge is distributed asymmetrically and decisions are taken unilaterally by headquarters, often without consultation of subsidiary managers. This type resembles the ethnocentric model identified by Gassmann and v.Zedtwitz (1999). There are several reasons for adopting this mode of governance and resource distribution: protection of original knowledge and proprietary technologies; extremely high quality requirements and misgivings concerning the capability of off-shore R&D to fulfill these standards; underutilization of R&D capacities at headquarters; and strong interest groups with political power that block decisions on decentralisation of R&D, because they see this as the first step of a larger process to transfer R&D work to low wage countries such as India, China, Eastern Europe or Brazil. In addition, MNC behaviour seems to be rooted in historical reasons, institutions and ideologies of the home countries (Doremus, Keller, Pauly, Reich, 1998).

³ Ghoshal and Bartlett (1990); Gupta and Govindarajan (1991); Forsgren and Pedersen (1998)

(2) Decentralized cooperative governance of R&D activities is characterized by symbiotic relationships among interdependent R&D units. It is similar to the “integrated network” coined by Gassmann and v. Zedtwitz (1999). As resource duplication is supposed to be almost absent, the ideal type of this governance mode functions without competition and bargaining, as resource and capability differentials between R&D units constitute the only criteria for project allocation. R&D projects are often realised conjointly by several dispersed units; for instance, the product concept may be developed by the Chinese subsidiary, the design is done by the Italians, for prototyping, the project is handed over to a German subsidiary, product validation is done in China and the US subsidiary may be in charge of the production process development. In other words, things are done where specialised knowledge and equipment is located.

(3) The decentralised competitive or market-like governance mode of R&D activities focuses cost efficiency when allocating projects among different R&D units of the MNC. While internal markets seldom exist in a pure form, R&D organisations characterised by a market-like or decentralised competitive governance mode exhibit the following characteristics (Birkinshaw, Fey, 2000):

- Several R&D units have similar technological resources and capabilities (duplications).
- There is competition among the R&D units over the allocation of R&D projects.
- Headquarters evaluate different locations for project and R&D role allocation on the basis of productivity, quality, responsiveness (time-to-market) and cost considerations. For this purpose, market prices, internal (transfer) prices or performance indicators are used.
- Consequently, R&D projects and R&D roles can be switched between R&D sites in response to performance and cost differences. This means that corporate R&D strategy gives preference to cost and performance differentials compared to other criteria, such as cultural and travel distance, specialised knowledge, size of the R&D unit, and so forth.
- Entrepreneurship (Birkinshaw 1998) can be crucial to draw attention to the potential and the performance of a peripheral R&D unit in a competitive internal market.

In a sense, a major difference between the ideal types of the centralised and the decentralised competitive governance mode is that the criteria for the allocation of R&D projects are transparent (performance, costs, quality, for instance). Moreover, every R&D unit has a chance to attract projects and resources as long as it is competitive compared to its sisters. A major difference between the decentralised cooperative and the decentralised competitive form is that underlying resources and product development capabilities differ from R&D unit to R&D unit in the former and overlap in the latter governance mode.

2.4 Institutional Environment and Relative Costs

Following North (1990, p. 4-5), the institutional environment refers to the “rules of the game” that “define and limit the set of choices of individuals”. More specifically, “the knowledge, skills and learning that members of an organization will acquire will reflect the payoff – the incentives – imbedded in the institutional constraints” (North, 1990, p. 74). As the institutional environments of different countries provide different payoffs or incentives for R&D activities, relative cost differentials can be considered a major outcome of institutional environments.

Thus we will focus on a major outcome of the institutional environment, the effect of relative cost incentives on R&D roles. Relative costs are of major importance for investment decisions of MNCs since they directly impact their competitiveness and can be exploited by companies with global presence. If relative cost differentials were sustainable over time, it would be attractive to move R&D projects between R&D units located in different countries. Brazil, China, India and Eastern European countries are particularly privileged because of low

relative costs, while possessing well-trained engineers and scientists. Relative costs have also been emphasised as important host country determinants (Birkinshaw/Hood 1998) or even as a “primary driving force” for MNC’s R&D activities in developing countries (Reddy 1997). However, there are still very few empirical works on this issue. For instance, Davis (2000) argues that cost saving is a primary motive for US pharmaceutical firms to do R&D in Denmark, since scientists, engineers and drug registration costs are lower than in the US. Cross-country studies on relative costs in R&D provide some evidence that countries which experienced a decline in relative costs like the US and the UK, have attracted foreign R&D between 1987 and 1998, while high cost countries such as Germany or Japan, reduced their share of global R&D (Dogherty 2003).

Though relative costs in R&D seem to grow in importance due to squeezed corporate R&D budgets, several prerequisites have to be met if MNC management intends to transfer R&D projects to cheaper locations. Firstly, sufficient technological capabilities in the potential host country must be available. Secondly, the MNC needs to know how to transfer technological knowledge across countries (Kogut/Zander 1993, Armbrecht et al. 2001, Schulz/Jobe 2001). Indeed, some scholars argue that global knowledge transfer is not always possible (Forsgren/Johanson/Sharma 2000).

Relative cost differentials change over time, are a combined outcome of the host country’s institutional environment and can be influenced by the host country’s government. Policy instruments can alter a country’s cost position relative to other countries which compete for foreign R&D investments.

First of all, there are direct subsidies or tax incentives (Cantwell/Mudambi 2000). An example of R&D incentives is the Brazilian ‘Informatics Law’, which grants industrial tax incentives provided that firms belonging to the information technology, telecommunication or automation industries produce locally and invest a certain percentage of sales either in in-house R&D or in R&D partnerships with research institutes and universities.

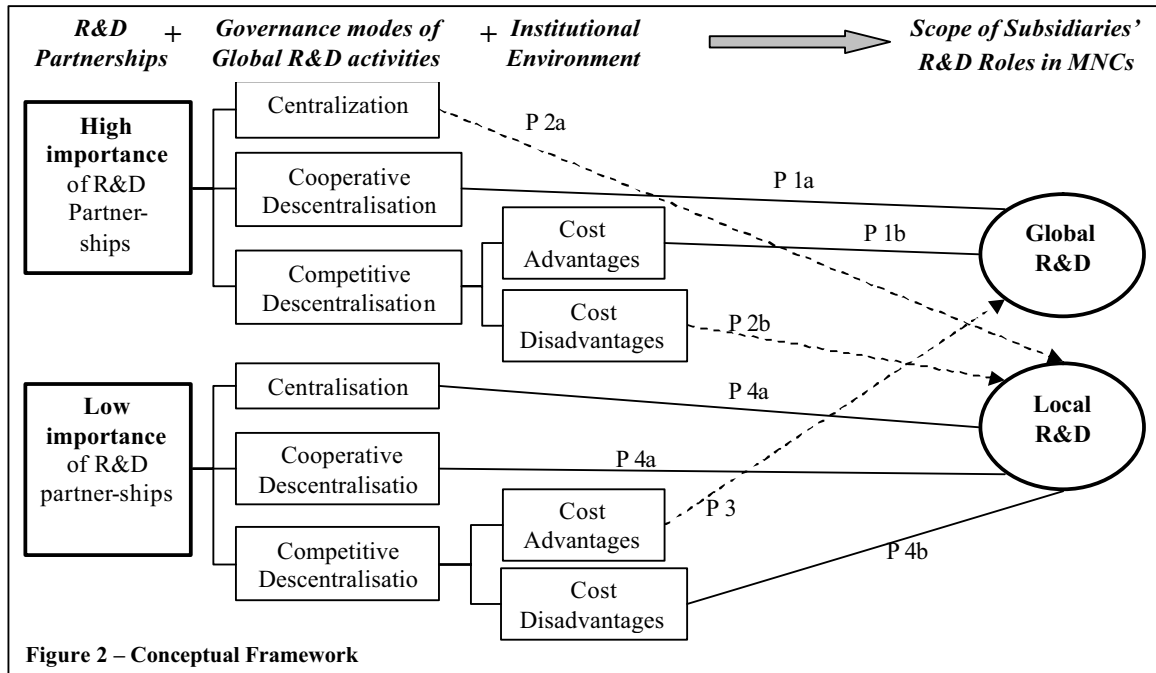
Secondly, macro-economic factors, such as currency fluctuations and wage levels, can generate low cost advantages relative to other countries. The combined effect of currency fluctuations and wage levels on R&D costs is particularly important since around half of manufacturing R&D expenditure in leading industrialised countries (France, Germany, Japan, Netherlands, UK, and USA) is attributable to wages (Dogherty/Inklaar/McGuckin/Van Ark 2002, p. 23). In addition, the relationship between wage levels and R&D output is influenced by the number of working hours; for instance, R&D personnel in Brazil work considerably more hours than R&D personnel in Germany, which increases wage cost differentials.

Thirdly, micro-economic factors, like fierce competition in the host country market, may pressurize R&D units to increase their efficiency, that is to say, reduce development costs by smarter project management (Clark/Fujimoto 1991, Fujimoto 2000). Competition has become an increasingly important factor after many host countries opened their markets to foreign competition.

Of course, this is no one-way street, since other factors may actually increase R&D costs: R&D costs rise when engineers and scientists become scarce and increase wage levels, when specialised laboratory equipment is not available, neither in the subsidiary nor through external partners, or the cross-border transfer of R&D inputs (raw materials, equipment) is difficult due to commerce barriers or bureaucratic hurdles. For instance, market prices of information technology, an important position of the non-wage-cost category (Dogherty/Inklaar/McGuckin/Van Ark 2002), are considerably higher in some peripheral countries like Brazil.

In sum, we pose that headquarters’ decisions regarding the global allocation of R&D projects and R&D roles can be influenced by economic factors which result in relative cost differentials. Whether headquarters are susceptible to relative cost considerations in R&D,

however, depends on governance mode of R&D activities. This is why the economic environment is linked only with the competitive decentralised governance mode (see Figure 2). Different combinations of the elements discussed the sections 2.2, 2.3 and 2.4 imply different geographical scopes of R&D roles in MNC subsidiaries as defined in section 2.1. The resulting relationships will be specified in section 3 using research propositions which are also referenced in Figure 2 (“P 1a”, “P 1b”, “P 2a”, “P 2b”, “P 3”, “P 4a”, “P 4b”). Whereas



the full lines in Figure 2 refer to outcomes in line with previous research on the relationships between R&D partnerships and subsidiary roles, the pointed lines indicate outcomes that have not been discussed yet.

3. A typology of foreign R&D units

Even though this paper attempts to make a theoretical point, it has been refined and enriched on the grounds of several open-ended in-depth interviews realised between 2001 and 2003 with R&D managers of more than 20 R&D units of MNC subsidiaries located in Brazil. Data was checked against secondary information from business newspapers and academic contributions. This approach enabled us to become familiar with the local business environment (competitors, suppliers, government regulations and local science base) of the R&D units selected for this paper.

Assuming that the importance of R&D partnerships and the R&D role can differ from one product family to another, we mainly focused on R&D activities in specific single product families and not on all R&D activities of a subsidiary. Furthermore, we assume that our typology is independent of industry or technology. In other words, we do not expect that R&D units belonging to a particular industrial sector to necessarily show similar patterns with respect to all four conceptual elements. We considered it reasonable to make the latter assumption after having applied within-case and cross-case analysis as suggested by Yin (1989) as well as Eisenhardt (1989). Yet, this assumption needs to be checked in future (large scale) surveys, since considerable industry differences regarding R&D intensity and relative R&D costs exist (Dogherty, Inklaar, Mcguckin, Van Ark 2002); consequently, the impact of the host country economic environment on R&D roles could possibly vary according to the industrial sector.

In each of the following subsections we connect the four elements of the framework as in Figure 2; following this, we present research propositions based on the preceding arguments and we conclude each subsection with case examples.

(I) Type I

As previous research suggests, global R&D roles are associated with strong partnerships. (Andersson, Forsgren 2000, Frost, Birkinshaw, Ensign 2002).

The first explanation is inspired by organisational studies, in particular, network and resource dependency theory (Ghoshal, Bartlett 1990, Andersson, Forsgren, Pedersen 2001, Andersson, Forsgren, Holm 2002). An R&D unit may access special resources via its external network of suppliers, clients, research institutes or universities. If other units of the multinational company depend on these special resources, then subsidiary management can ask for something in return. The ‘currency of exchange’ may consist of knowledge assets, financial resources (a larger budget for new investments), the attribution of further R&D projects or formal recognition by headquarters as a major R&D unit of the MNC. A major R&D unit may become involved in important global projects and involvement in global projects often requires even more capabilities and resources. Furthermore, the MNC may be forced to transfer resources to the subsidiary in order to match the structures of the local or business network (Ghoshal, Bartlett 1990, p. 613). Accordingly, a networked R&D unit which participates in global projects is in a favorable position to further develop its technological capabilities taking advantage of both its external and internal MNC network.

A second, complementary explanation is that a dense network of external R&D partnerships makes it more difficult for headquarters to control the subsidiary (Holm, Johanson, Thilnius 1995, Andersson, Forsgren 1996); this problem can be attributed to the implications of bounded rationality (Simon 1947). Insufficient or ineffective control by headquarters may create a ‘vacuum’ where subsidiary management can implement their own strategies in order to build up technological capabilities in cooperation with external partner organisations.

A third explanation is that close cooperation with R&D partners creates tacit knowledge over time, as the interactions between members of several organisations help to accumulate context specific experience in R&D management and technical matters. This makes information and knowledge “sticky” (v. Hippel 1998) and more difficult to transfer elsewhere. Accordingly, the R&D unit may be in a position to preserve a certain knowledge gap compared to sister R&D units (Rugman, Verbeke 2001).

However, even though these arguments seem to be compelling, they are probably not sufficient under the following hypothetical conditions: the governance mode of R&D activities may be strongly centralised and impede participation in global roles. If the governance mode of R&D activities were decentralised and competitive, a strong network of R&D partnerships would probably be insufficient to compete against R&D units in other countries which enjoy relative cost advantages. Therefore, the decentralised cooperative governance mode tends to most favorably support the type I relationship, since specialised knowledge and R&D infrastructure (be it internal or external) are decisive for R&D project allocations. The preceding arguments can be stated in the following formal propositions:

Proposition 1a: Foreign R&D units with strong R&D partnerships are likely to perform a global R&D role if the MNC has adopted a decentralised cooperative governance mode of R&D activities.

Proposition 1b: Foreign R&D units with strong R&D partnerships are likely to perform a global R&D role if the MNC has adopted a decentralised competitive governance mode of R&D activities and if the host country institutional environment provides cost advantages over sister R&D units.

An example for the type I or the “Networked Global R&D unit” is *International Engines South America*, which produces and develops high speed Diesel Engines in Brazil. The Brazilian subsidiary can be considered a Global Subsidiary Mandate for high speed diesel engines due to its unrivaled competence within the MNC. The São Paulo based R&D unit is a sort of systems integrator which works closely together with its main component suppliers and specialised technology partners based in different countries (mainly Europe and Brazil). After International Engines bought the formerly Brazilian owned company, a high degree of operational autonomy has been preserved as its new Brazilian subsidiary complements very well the product range of International Engine’s US-based activities. Recently, US-based and Brazilian-based R&D activities are being closer coordinated. All this indicates that the governance mode of R&D activities is decentralised and cooperative.

Siemens’ telecommunications R&D unit is one of 10 centres of excellence in a specific business unit and contributes to global development programs managed by headquarters. Tax incentives (‘Informatics Law’) for investments in R&D partnerships have been used to build up a strong network of local R&D partners (universities and independent R&D institutes). The partners received heavy investments in equipment and training from Siemens during the boom years of the telecommunications industry, from the mid 1990s until 2001. For instance, partner R&D institutes close to the plant in Curitiba received more than US\$ 15 million in that time. In response to increasing cost pressures from 2002 onwards, Siemens’ Brazilian R&D unit was required to reduce internal headcounts and transferred part of their engineers to its main external partner. Hence, many employees of these partner organisations are still highly familiar with Siemens’ corporate culture and maintain strong personal relationships with its staff. Thus R&D partnerships have become increasingly important to maintain the critical mass essential for participating in global R&D projects. This external infra-structure is recognised by headquarters and was a crucial factor when decisions on the attribution of global responsibilities such as centres of competence were made. Among other quantitative and qualitative criteria, development costs are a very important criterion for the attribution of R&D roles and competition among Siemens’ subsidiaries has become intense during the last decade.

Thus, while International Engines fulfills proposition 1a, Siemens tends to satisfy proposition 1b.

(II) Type II

The existence of R&D units with a supportive role and partnerships of high importance to product development activities is counter-intuitive, since strong external partnerships are associated with global roles in R&D (see previous section). Though these relationships with local partners could provide the MNC with important knowledge of global products, a centralised mode of governance as indicated in section 2.3 (1) can block the subsidiary’s R&D units from participating in global R&D. Thus:

Proposition 2a: Foreign R&D units with strong external R&D partnerships are likely to perform a local R&D role if the MNC has adopted a centralised governance mode of R&D activities.

However, there is a further situation that explains type II R&D units: the mode of governance could be decentralised and competitive while the unit had a less favorable cost position compared to sister R&D units with similar technological capabilities. In such a situation, R&D activities are likely to be transferred to a cheaper unit.

Proposition 2b: Foreign R&D units with strong external R&D partnerships are likely to perform a local R&D role if the MNC has adopted a decentralised competitive

governance mode of R&D activities and if the host country institutional environment provides cost disadvantages over sister R&D units.

Dana-Spicer adapts, develops and produces drivetrains in South Brazil. Product development is tightly aligned with the individual requirements of strategic local customers such as the truck divisions of DaimlerChrysler and Volkswagen. Dana-Spicer is prepared to satisfy whatever specific requirement of DaimlerChrysler in order to avoid that DaimlerChrysler's own drivetrain division enters the Brazilian market. Thus continuous local R&D activities are indispensable in order to be always a pace ahead of potential competitors. The R&D partnership has been built up over decades and makes it particularly stable. Another strategic client, Volkswagen, produces trucks only in Brazil and customizes its new products to the specific requirements of end users. Because of this product strategy, part suppliers such as Dana-Spicer need to adapt their products accordingly. Although these R&D partnerships with clients are strong and highly strategic, Dana-Spicer does not contribute to global R&D of the MNC. Instead, global R&D is concentrated in the US and Germany in conformity with the market segment. Hence, Dana-Spicer's governance mode of R&D activities is centralised and reflects proposition 2a. Accordingly, Brazil's considerable development cost advantages relative to the US, Germany and Japan do hardly influence decisions on R&D projects assignments.

The R&D unit of **Hewlett Packard** is located in a technological park managed by a major private university in South Brazil. It has created a dense, trust-based network with Brazilian research institutes and universities, which focuses on basic and applied research. R&D management intends to use this research capacity in order to qualify for becoming an HP-Lab; HP-Labs carry out basic and applied research for the global market. Currently, only five HP Labs exist worldwide, two of them in low wage countries (India and China). As for the governance mode, HP practises decentralised R&D, but it seems to be ambivalent regarding competition between R&D units. On the one hand, Birkinshaw, Fey (2000) have identified some competitive elements such as a "bottom-up process" at HP, which creates incentives for R&D managers to bid for or request specific projects. There are also several units which could carry out any R&D project. Furthermore, in fact, Brazilian R&D costs are higher than the Indian and Chinese ones. All three reasons point clearly towards proposition 2b respectively. On the other hand, local R&D management plays down the importance of development costs and attributes its competitive disadvantages to better internal networking of Indian R&D managers, which points to a negative organisational power balance. For this reason, future research is needed in order to clarify the issue.

(III) Type III

This third type – global R&D and low importance of external R&D partnerships – is also counterintuitive, since there are several theoretical arguments and much empirical evidence that global R&D work is associated with high importance of external R&D partnerships (see reasoning on type I).

We argue that type III R&D units arise when the governance mode of R&D activities is decentralised competitive, sometimes called "internal market" (Birkinshaw, Fey 2000), and when, simultaneously, the host country's economic environment provides relative cost advantages to the R&D unit. In other words, when governance of R&D activities permits cost competition among R&D units, the cost advantages of a particular host country can translate into competitive advantages over sister units provided that the technological capabilities of competing R&D units are comparable. If an R&D unit's cost advantages are sufficiently high and sustainable, it can attract global R&D projects outcompeting its sister R&D units in other countries.

There are two reasons why performing global R&D without being involved in important R&D partnerships for product development is not possible under alternative combinations of our framework's elements. Firstly, a centralised governance mode of R&D activities would rule out the focal R&D unit's participation in global projects. Second, if a cooperative decentralised governance mode were adopted, relative cost advantages would be less important compared to organisational factors, such as R&D resources, the continuous access to valuable knowledge for new product development from external partners and power relationships, among others.

Based on this reasoning, we propose that:

Proposition 3: Foreign R&D units without significant R&D partnerships are likely to perform a global R&D role, if the MNC has adopted a decentralised competitive (or market-like) governance mode of R&D activities and if the host country's institutional environment provides cost advantages over sister R&D units.

The following examples illustrate this point: **SpringerCarrier**, an air-conditioning manufacturer, obtained its first global responsibility as a design centre for product platforms of wall-rested air-conditioners at the end of the 1990s. After heavy cost cuts in 2001, the R&D unit is again on a course of growth and gained its second global responsibility in 2003 for the development of a split air-conditioners family. As for R&D partnerships, there are only some sporadic university contacts in order to cover specific needs in technological services; new knowledge, however, is provided by the US-based central research site.

As for the corporate environment, several R&D (or 'lead design centres') of Carrier Corporation compete for resources and project allocations. The capabilities of competing centres are quite similar and projects are allocated to high performers in costs, lead time and quality. Sometimes, cost and time targets are very ambitious and going for projects requires strong entrepreneurial spirit.

Yet, the Brazilian host country economic environment provides some competitive advantages: first of all, successive currency devaluations, which started in 1999, reduced relative prices compared to competing Italian, French, South Korean or Mexican design centres (macroeconomic incentive).

There is also a strong microeconomic incentive for innovation and efficiency orientation: the Brazilian market for refrigeration equipment is one of the most competitive in the world since several new MNCs have entered the market during the last few years. Combined with this, the Brazilian government stimulates competition even more, awarding premiums for those companies whose products achieve lower energy consumption targets. As award winners may market their superior performance to customers, competitive pressure increases.

In summary, Carrier Corporation seems to have adopted a decentralised competitive mode of corporate governance as far as product development is concerned. The Brazilian R&D unit obtained global development responsibilities because it is highly cost competitive over sister units due to the host country environment (currency devaluation and strong competition), which resulted in internationally highly competitive wages and internal, development process-related cost reductions.

Ericsson's software development unit based in São Paulo State owes its current size (around 250 employees in 2003) to tax incentives ('Informatics Law'). Partnerships with seven Brazilian universities and research institutes exist due to the requirement of the 'Informatics Law'; however, they are not related to the global software development responsibilities of the unit. While the partnerships are long-term oriented and contribute to headquarters' hardware development projects, the R&D unit's software development is of shorter duration. The unit has software development responsibilities for Ericsson's global

telecom switching platform. Proprietary software is increasingly important to gain a competitive edge as hardware is, more and more rapidly, turning into a commodity.

The form of corporate governance is characterised by an “extraordinary amount of control”, “communication” and “a high level of interdependence between units” (Nobel, Birkinshaw 1998, p. 491). Moreover, Birkinshaw, Fey (2000, p. 173) concluded in their case study research that Ericsson is quite close to the internal market approach (named ‘decentralised competitive mode of corporate governance’ in this paper).

Personal interviews indicated that headquarters evaluate R&D units according to performance indicators (development costs, time and quality). According to costs, the Brazilian unit is considered a low cost site (compared to high cost sites in the US, Germany or Switzerland and medium cost sites in Italy, for example). In this respect, the Brazilian unit directly competes with R&D units in Eastern Europe and Asia. Internal competition stimulates R&D units to improve the software development process and be certified by the Capability Maturity Model (CMM).

The host country’s economic environment (currency devaluation and ‘Informatics Law’) has reduced the R&D costs of the Brazilian unit compared to its sister units. In addition, the ‘Informatics Law’ created R&D capacities which had to be filled somehow. Hence, projects from high cost countries such as the US have been transferred to Brazil. On the other hand, the reduction of tax incentives after 2001 has reduced cost advantages and consequently translated into a downscaling of R&D activities.

To conclude, both examples illustrate that R&D units without relevant external partnerships for their product development activities can be assigned global R&D roles as long as the decentralised competitive (market-like) governance mode is matched by a host country’s relative cost advantages. Both examples differ regarding the economic mechanisms that produce relative cost advantages.

(IV) Type IV

Turning the arguments of type I around, type IV can be easily explained: R&D units without significant R&D partnerships have less access to new knowledge distinct from internally available knowledge of the MNC. Therefore, they strongly depend on headquarters’ central R&D or other MNC R&D units as technology and knowledge suppliers. Gupta, Govindarajan (1991, p. 774), for example, mention that implementers do not create new knowledge and “rely on knowledge inflows from either the parent or the peer subsidiaries”. Similarly, Nobel, Birkinshaw (1998, p. 488) confirm that “local adaptors have essentially no links with universities, even local ones”.

As noted before, this criterion is important but not sufficient, since R&D units with weak partnerships may, under certain conditions, become involved in global R&D (see type III). There are two additional conditions which limit type IV units to local adaptation: as in type II, a centralised mode of corporate governance is likely to inhibit the development of the R&D unit. Accordingly, we suggest that:

Proposition 4a: Foreign R&D units without significant R&D partnerships are likely to perform a local R&D role if the MNC has adopted a centralised or a decentralised cooperative governance mode of R&D activities.

Under the decentralised competitive mode of governance and economic disadvantages, a global R&D role is even less likely.

Proposition 4b: Foreign R&D units without significant R&D partnerships are likely to perform a local R&D role if the MNC has adopted a decentralised competitive governance mode of R&D activities and if the host country institutional environment provides cost disadvantages over sister R&D units.

The following examples illustrate both possibilities: *Audi*, for instance, does all product development at its corporate R&D centre in Germany. Even more resistant suspension systems for rougher street conditions in emerging markets are developed by central R&D. As a premium product conceived for high income industrialised countries, quality control and image reasons may account for this extreme, ethnocentric posture. R&D activities in Brazil have been focused on substituting imports of parts. In order to achieve this, local suppliers have been found in order to substitute more local parts for expensive imported ones. Yet, in some cases, Audi had to slightly modify the original engineering project, because the subsidiary had to find much cheaper, less sophisticated components in order to increase competitiveness in the Brazilian market. However, given the dominant position of central R&D and a clear centralised mode of governance, eventual host country advantages become irrelevant. Consequently, this example satisfies proposition 4a.

Alcatel's R&D unit counted on strong partnerships until the 1990s: the company acquired several local telecommunications companies which were tightly embedded into the former Brazilian telecommunications innovation system (Szapiro/Cassiolato, 2003). In addition, as in the cases of other telecommunications companies mentioned in this study, the 'Informatics Law' provided incentives to foster external networks with local research institutes and universities. However, the former R&D partnerships have become obsolete because global technological standards in telecommunications made local adaptations and indigenous technology mostly redundant. In response to global competition and the crisis of the telecommunications industry, Alcatel concentrated production and R&D activities in order to realise scale economies. Global R&D was concentrated from 23 to five major units. Competition for survival between R&D units negatively affected the Brazilian unit for two reasons: firstly, the abandonment of local production in Brazil eliminated tax incentives; secondly, other R&D units, like the Chinese, have cost advantages over the Brazilian unit. Consequently, Brazilian R&D activities became uncompetitive in comparison with sister units and had to be discontinued after the year 2000. Thus, this example reflects proposition 4b.

4. Discussion and Conclusions

Our arguments and anecdotal examples indicate that MNC headquarters can attribute global R&D roles (such as design centres, centres of competence or excellence, or world

	Product development for global markets	Product development for the local market
High importance of external R&D partnerships	<p>Type I</p> <p><i>Organisational Power balance benefits the focal R&D unit</i></p>	<p>Type II</p> <p><i>Organisational Power balance or the institutional environment disadvantage the focal R&D unit</i></p>
Low importance of external R&D partnerships	<p>Type III</p> <p><i>The institutional environment benefit the focal R&D unit</i></p>	<p>Type IV</p> <p><i>Organisational Power balance or the institutional environment disadvantages the focal R&D unit</i></p>

mandates) to subsidiaries without significant R&D partnerships (type III R&D units). Moreover, we found two reasons why strong R&D partnerships do not necessarily imply global R&D roles. This complements the empirical results presented by Andersson, Forsgren, Holm (2002) and Frost, Birkinshaw, Ensign (2002). Consequently, "the subsidiaries' business network" (Andersson and Forsgren 2000, p. 333) does not always sufficiently explain R&D roles within MNCs. In addition to

Figure 3: The influence of Organisational Power and Economic Drivers on R&D Roles

R&D partnerships, different governance modes of global R&D activities and the outcomes of the host country's institutional environment in terms of cost competitiveness needs to be considered in order to explain R&D roles.

So, why did previous large scale surveys overlook type II and type III R&D units? One possible answer could be found in characteristics of the empirical samples. The mentioned surveys were carried out in industrialised countries, such as Britain, Canada, Sweden or Denmark. Since R&D cost differentials among industrialised countries can be expected to be much smaller than between developing and industrialised countries, type III R&D units could not be detected or simply do not exist. Furthermore, the impact of host country cost advantages on R&D roles can only be revealed when the decentralised competitive mode of governance is taken into account.

This gives rise to the question of whether the proposed typology is also generalisable to countries other than emerging economies with well-developed human capital (engineers and scientists) and low cost characteristics. Although it is conceivable that MNCs also exploit cost differentials among industrialised countries, these differentials are likely to be smaller than between industrialised and emerging economies. Therefore, cost factors probably decrease in importance relative to other factors such as science and technology infrastructure, distance and path dependency, among others. Thus, a future research agenda should contemplate whether our findings are limited to some peripheral countries and to what extent they can be extended to industrialised ones.

We may now return to our initial research question: what does the location of more advanced R&D roles really influence – institutional economic or organisational drivers? As Figure 3 illustrates, type I relies heavily on organisational power resulting from the external network which is highly important for R&D activities and thus for the success of the R&D unit as provider of new solutions for the global market. This position can be reinforced when the R&D unit also has cost advantages over sister units and when R&D costs matter for the MNC's governance mode of R&D activities. The most sustainable R&D roles are probably those which manage to draw organisational power and cost advantages out of their R&D partnerships at the same time. As Type II shows, however, R&D cost disadvantages can offset the benefit derived from the organisational power base if R&D costs were relevant for the MNC's governance mode of R&D activities. Moreover, the power balance in the MNC can also be unfavorable for the focal subsidiary as the HP example has shown. Yet, Type III is clearly based on cost advantages without any power base. This makes it highly vulnerable to major shifts in its cost position or crisis in the MNC. As the Ericsson example illustrates, a reduction of tax incentives between 2001 and 2003 led to a drastic shrinkage of R&D activities and around 50% of R&D personnel were made redundant. It is remarkable that the major currency devaluation in 2002 could not make up for the loss in tax incentives, which could possibly be explained by Ericsson's deep global crisis and restructuring. As headquarters may restrict the subsidiary's options to build a proper power base by R&D partnering, alternatives to maintain the global R&D role against an adverse economic environment are limited to internal R&D process improvements. In other words, the focal R&D unit needs to increase its internal efficiency in order to become less dependent on fluctuations of the external economic environment. When the focal R&D unit has neither cost advantages nor an organisational power base, then it may become simply irrelevant for global R&D activities (Type IV).

In conclusion, both economic and organisational drivers are equally important to explain R&D roles. Hence, a theory of R&D roles should take both theoretic approaches into account. Yet, the relative importance of either driver depends ultimately on the governance mode of global R&D activities.

Evidently, our conceptual framework suggests several questions. Among other issues, it could be asked to what extent technology related factors may have an influence on economic and organisational power drivers. We tentatively set out some of them below, but they are contradictory to some degree and it is still far from evident how these factors interact with the elements of our conceptual framework - an issue that also merits extensive future research.

First, the necessity to create R&D partnerships, for instance, seems to depend on the maturity of an industry or of a particular product. When technologies are mature and technological progress slow, there is less necessity to build up partnerships than in high-tech industries where progress is fast and knowledge creation more costly (see for example Powell/Koput/Smith-Doerr 1996). Yet, there are exceptions such as our Dana-Spicer example.

Conversely, mature technologies seem to be more susceptible to cost-efficiency considerations than completely new technologies. Mature industries tend to privilege process innovation since opportunities for new product innovation are rare and competitive dynamics shift the focus towards low cost and low margin products. Correspondingly, industry maturity may provoke a shift in R&D strategy towards cost reduction by R&D process improvements or relocating R&D to low cost countries. However, there are counter-examples, for instance, the India-based pharmaceutical research unit of Astra carries out cutting edge research projects and has global responsibilities (Reddy/Sigurdson 1997). Behind this, arises an additional question: what activities of the entire R and D process are more sensitive to cost considerations? While costs seem to increase in significance as R&D projects move through product development stages towards market introduction (Kay 1988), wage costs, which account for around 50% of R&D budgets in industrialised countries, tend to be higher in upstream research activities (Dogherthy/Inklaar/McGuckin/Van Ark 2002).

Second, it seems to be a common characteristic of system integrators, such as the example of International Engines (type I), to rely on technology suppliers. These relationships are different from market exchange, require close cooperation between system integrators and their component suppliers and help to improve the internal knowledge base. The trend is that system integration is becoming increasingly important as more and more technologies and components need to be incorporated into final products (Dosi/Hobday/Marengo/Prencipe 2002). Thus, a subsidiary with system integration responsibilities can be expected to have sustainable and strong R&D partnerships which make it eligible for a global R&D role no matter of cost considerations.

Third, there is a trade-off between economic or cost advantages and required investments in technological infra-structure such as laboratory equipment: if the latter were high, the former would have limited impact and vice-versa. In other words, R&D cost advantages will only matter if R&D infra-structure already exists in the host country, if it is comparatively cheap (as in software development) or if the local government pays for it. Both of our type IV cases demonstrate this: SpringerCarrier built up its R&D infra-structure when markets were still closed (in the 1980s) and inherited part of the infra-structure from the former Brazilian owner. Also, Ericsson's investments in R&D infra-structure have indirectly been paid by government money (tax exemptions).

The implication of this is that technological factors seem to influence the decision of whether a subsidiary builds up R&D partnerships as well as its possibilities to benefit from cost drivers. However, future research is needed to draw more generalisable conclusions about the impact of technological factors relative to organisational and economic drivers.

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