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Patterns of R&D Configuration and Evolution in MNCs

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Abstract

State-of-the-art

Global distribution of R&D has been interpreted as a strategic decision of firms who attempt to exploit their innovation advantage to compete in an increasingly globalized environment. However, firms with similar geographic distribution are heterogeneous in their ability to exploit the benefits of geographic reach to enhance the quality of their innovation (Lahiri, 2010). This challenges multinational firms to devise an appropriate technology strategy and to manage the global configuration for R&D accordingly.

Research Gap and Theoretical Arguments:

According to the dispersion of R&D activities and the degree of cooperation between individual R&D units, Gassmann & von Zedtwitz (1999) suggested a new classification of R&D configuration: ethnocentric centralized, geocentric centralized, polycentric decentralized, R&D hub, and integrated R&D. More recently, Gassmann and von Zedtwitz (2002) identified four archetypical forms of international R&D organization: national treasure, market-driven, technology driven and global. Meanwhile, Birkinshaw (2002) recognized that there are two ways of managing the entire R&D organizational structure: integrated R&D, loosely-coupled. DeSanctis (2002) also proposed three organizational designs which are being used to manage distributed R&D organizations: decentralized, networked and integrated.

In recent years, more emerging countries, such as China, Brazil and India, play an important role in the international R&D strategies of many MNCs. While the continued growth of R&D globalization in emerging countries has been highlighted in the literature, little attention has been devoted to the question of whether the configuration patterns have evolved along with the emergence of new R&D destinations.

Thus, in my study, I examine the patterns of R&D configuration in MNCs and the evolution. In particular, I investigate whether there is entirely new pattern beyond the scope of the existing literature and co-existence of different patterns of R&D configuration in a large multinational firm.

Method

The first part of the study was a field research in Brazil. It was conducted with a group of R&D managers from 10 large MNCs. During the learning trip to Brazil, we interviewed senior R&D managers/directors from R&D centers of 3 large multinational firms (GE, IBM, and Siemens) and 3 large Brazilian firms (Natura, Embraer, and Petrobras). The second part of the study was a questionnaire survey conducted at EIRMA Representatives Round Table Event 2013 (EIRMA, European Industrial Research Management Association). Senior managers/executives responsible for controlling the entire R&D organization from 13 large MNCs filled the questionnaire completely.

Main Results

(1), this study contributes to the literature by deriving and testing a new typology of R&D configuration patterns. The new typology (including four archetypical patterns of R&D configuration: Satellite Network, Upgrade Satellite Network, Loosely-coupled Network, and Integrated Network) has included all main findings in the literature. All firms I investigated in this study could find a corresponding pattern from the four archetypical patterns; (2), evolution from one pattern to another indeed exists in the firms I studied; however a trend towards the integrated R&D network is not clear. This result is inconsistent with the finding in the literature; (3), although we do not find any entirely new pattern of R&D configuration, we notice that different archetypical patterns are often mixed in large MNCs. The mixture of different configuration patterns may vary across the countries and business units.

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Abstract

Global distribution of R&D has been interpreted as a strategic decision of firms who attempt to exploit their innovation advantage to compete in an increasingly globalized environment. In this study, we examine the patterns of R&D configuration in MNCs and the evolution. In particular, we investigate whether there is or not an entirely new pattern beyond the scope of the existing literature. We also focus on dynamics: does the R&D configuration evolve from one pattern to another and how? This study contributes to the literature by deriving and testing a new typology of R&D configuration patterns. The new typology includes four archetypical patterns of R&D configuration: Satellite Network, Upgrade Satellite Network, Loosely-coupled Network, and Integrated Network. All firms we investigated in this study could find a corresponding pattern from the four archetypical patterns. Furthermore, we observe that in the last five years there has been extensive dispute over the organizational evolution in sample firms of this study. The trend towards the integrated R&D network isn't evident. This result is inconsistent with the finding in the literature. Last, we identify that different archetypical patterns are often mixed in large MNCs. The mixture of different configuration patterns may vary across the host countries and business units.

Keywords: R&D globalization, R&D organization, network, configuration

Introduction

One of the major reasons why MNCs exist is their ability to globally leverage dispersed subsidiary-specific advantages and to generate new knowledge through a global synthesis of dispersed knowledge (Almeida and Phene 2004). These abilities constitute a major source of competitive advantage for MNCs (Andersson et al. 2002). Global distribution of R&D has been interpreted as a strategic decision of firms who attempt to exploit their innovation advantage to compete in an increasingly globalized environment (Global R&D Report, 2007).

While numerous studies have provided evidences to prove that the distributed R&D strategy can increase the extent of knowledge flow between the individual units and their respective host regions (Singh, 2005), firms with similar geographic distribution are heterogeneous in their ability to exploit the benefits of geographic reach to enhance the quality of their innovation (Lahiri, 2010). The relationship between the geographic distribution of R&D activity and a firm's overall innovation capability is ambiguous since gains from access to talents and knowledge from different regions could be offset by costs of coordination and difficulty of control and knowledge integration across distant R&D units. In the other words, there is no evidence that distributed R&D in itself improves values of a firm's innovation (Singh, 2008).

For executives responsible for R&D in multinational firms, then the main challenge is to find an effective means to configure their geographically distributed R&D activities according to their corporate technology strategy. In the literature, it is somewhat surprising that so little research has focused on the issue of how dispersed R&D units with different missions are integrated together. After more than a decade of widespread global R&D expansion, managing the geographically distributed R&D activities with an effective structure is still widely recognized as one of the most persistent challenges facing MNCs (Birkinshaw, 2002; Thamhain, 2009). Andersson and Pedersen (2010) identified that much of the literature that focuses on the issues of knowledge transfer and control management in the global R&D organization has ignored the importance of R&D global configuration design.

Continued rapid growth of R&D globalization in emerging countries makes R&D configuration in a global scope a very complex task. Many multinational firms have recently expanded their R&D activities into carefully selected emerging countries, such as Brazil, Russia, India and China (Sun, et al. 2007). The mission of these R&D centers has started

shifting from traditional supporting roles to becoming critical components of their global R&D network (Sun, et al. 2007). This recent trend is challenging large multinationals to strategically organize their global R&D configuration in a more complex context. As the emerging markets grew explosively in the first decade of the 21st century, multinationals raced to develop new strategies to meet the new challenges. While the continued growth of R&D globalization in emerging countries has been highlighted in the literature, little attention has been devoted to the question of dynamics: does the configuration pattern evolve along with the emergence of new R&D destinations?

The main purpose of this paper is to examine the patterns of R&D configuration in MNCs and the evolution. In particular, (1) we investigate whether there is or not an entirely new pattern beyond the scope of the existing literature, and (2) we focus on dynamics: does the R&D configuration evolve from one pattern to another and how? The paper is organized as follows. We first provide some theoretical background on organization design of global R&D in MNCs. In particular, we review and classify previous studies that have tried to construct typologies of global R&D configuration by defining the specialization of R&D units and their interdependence. This literature allows us to develop a new typology of R&D configuration that includes four archetypical patterns of R&D configuration: Satellite Network, Upgrade Satellite Network, Loosely-coupled Network, and Integrated Network. The next section then introduces the research method and data collection used in this study. Specifically, we describe a field study in which the hypothesized archetypical patterns of R&D configuration and the implementation of R&D globalization strategy by foreign MNCs in Brazil are examined. Furthermore, we systematically examine the new typology of R&D configuration patterns and the evolution with survey data from 13 large multinational firms. The results of the empirical test of the four archetypical patterns of R&D configuration are subsequently described. A final section then summarizes and discusses our findings, provides recommendations for future research.

Theoretical Background

When corporate competitive advantages can depend heavily on a firm's ability to innovate rapidly with maximum business impact and rigorous cost control, organization design issues have start attracting scholars' attention (Porter, 1990; Daft & Lewin 1993). While companies

are seeking value from their R&D initiatives, the potential payoffs from organizing R&D effectively are enormous and the costs of ineffective organization structures extremely high (DeSanctis, Glass, Ensing 2002). Gerybadze & Reger (1999) found that many firms have started to search for leaner and more effective ways of managing their international portfolios of innovation activities as a result of the overly complex and unmanageable organizational architectures associated with distributed R&D activities and globally dispersed innovation processes. Organizations are moving from reliance on hierarchy and rigidity of structure to new forms that are flatter, cross-functional, and dynamic (DeSanctis, Glass, Ensing, 2002). Firms seek to be both innovative and efficient, global and local, disciplined and flexible (Child, McGrath, 2001). The first part of this section will provide a brief literature review concerning organizational theories, subjects that help explain how the R&D activities are geographically distributed and effectively integrated taking their organizational structures into consideration. A subsequent part will review and classify previous studies that have tried to construct typologies of global R&D configuration by defining the specialization of R&D units and their interdependence.

Work Design: Specialization

Two basic principles of work design identified from the literature play an important role in global R&D management:

(1) Functional specialization

Kuemmerle (1997) found that the overwhelming majority of foreign R&D sites fell clearly into one of the two categories – home-base exploiting and home-base augmenting. "Home-base-exploiting sites", are located close to large markets and manufacturing facilities in order to commercialize new products rapidly in foreign markets. "Home-base-augmenting sites" are established in order to tap knowledge from competitors and universities around the globe; in this site, information flows from the foreign laboratory to the central laboratory at home, and they are often located in regional clusters of scientific excellence in order to tap new sourcing of knowledge.

Von Zedtwitz and Gassmann (2002) first identify two principal reasons that lead to different patterns of international R&D management - access to market and access to science. For market seeking companies who try to further exploit their own technology in a broader market, establishing product development centers in certain emerging markets should also

be seen as a rational strategy. For knowledge seeking companies who try to profit from such globally dispersed reservoirs of knowledge, establishing research activities in certain knowledge-intensive regions should be seen as a conscious strategy.

(2) Geographic specialization

Historically R&D operations were centralized, and this organization design persisted long after World War II. Even as the organizations grew, diversified, and spread across the globe, R&D remained centralized in many companies. In a domestic centralized R&D organization, almost all R&D activities are concentrated in the home country. This R&D configuration model has been described in several previous studies with various terminologies, such as ethnocentric centralized R&D, geocentric centralized R&D (Gassmann and von Zedtwitz, 1999).

In a form of multidomestic R&D organization, all R&D activities take place within the subsidiaries/independent business divisions/business units. There won't be any project collaboration between each self-contained R&D centers, since these self-contained R&D centers are typically unique within the corporation in perspectives of technology skills, knowledge assets and target markets. The self-contained R&D centers are always managed with a high level of autonomy, as it is up to the R&D center itself to figure out how best to meet the market needs (Porter, 1986; Ghoshal & Bartlett, 1990).

Along with the increasing corporate R&D internationalization, several researchers identify an evolution from centralized or multidomestic R&D gives way to hub or network-like organization structures which is mainly characterized by knowledge sharing and collaboration. The global R&D configuration evolves into a R&D unit among many other interdependent R&D units which are closely interconnected by means of flexible and diverse coordination and control mechanisms (Gassmann and von Zedtwitz, 1999, 2002).

Work Design: Interdependence

In the literature of MNCs, interdependence was defined as the reliance of each sub-unit of the MNC, including corporate head office, on other sub-units for its operations (O'Donnell, 2000). Further theory views interdependence as arising from the integration of internationalization (Ghoshal and Nohria, 1989) and the global positioning of MNCs (Morrison and Roth, 1992). As Bartlett and Ghoshal (1989) said "interdependence…breaks

down the hierarchy between local and global interests by making sharing of resources, ideas and opportunities…a self-enforcing norm". The characteristics of MNCs sub-units as receptacles of differentiated knowledge (Frost, 2001) resulted in an understanding of interdependence across sub-units as complementing and assimilating specialized strands of expertise (Subramaniam and Venkatraman, 2001).

R&D activity has always been considered as a complex task, characterized by its high degrees of uncertainty and ambiguity. Furthermore, R&D activities may need to be conducted based on a large database. According to the interdependence theory, the nature of R&D task results in a high level of stickiness between different R&D tasks. Thus, the strategy decision of global distribution of R&D should start with an assessment of the overall stickiness of the R&D task and to identify potential solutions to minimize the stickiness (Kumar, 2009). Another solution suggested by Kumar (2009) is to divide the R&D task into several segments that can be relatively independent, with an expectation to fit the outputs of all individual segments into an integrated package. Andersson and Pedersen (2010) assumed two typical developments concurrently for reaping the benefits of the new global opportunity in R&D: "(1) more disaggregation of the value chain activities, during with standardized activities are separated from more advanced activities, and (2) more global dispersion of those value chain activities aimed at tapping into new knowledge and talents". Therefore, the recognition of interdependence theory and its typology may be helpful for organization designers to manage the interdependence and interfaces between the dispersed R&D activities, in order to achieve optimal benefits from R&D global distribution. Some scholars further investigate and categorize the overall interdependence profiles of subsidiaries in MNCs.

Along two basic dimensions: scope of interdependence (from narrow to broad) and direction of primary influence in the interdependence (unidirectional or multidirectional), four distinct profiles of interdependence at subsidiaries of MNCs were defined (Subramaniam and Watson, 2006):

Lone Star is a type of sub-units characterized by a low degree and a narrow scope of interdependence, with no significant influence directed at any other sub-units. According to Porter (1986), this "lone star" interdependence profile could exist in multinational firms competing in multi-domestic industries where there is few necessity to coordinate activities across country markets. Therefore, the sub-units located in each country are mainly

responsive to their local market needs and are not affected by activities in other country. This interdependence profile is consistent with transaction cost approach (Williamson, 1981) in which so many organizational types exist because each is optimized for different types of transactions. *Passive Star* is a type of sub-units characterized by a moderate degree of interdependence which is typically limited to the relationship between sub-units and headquarters. There is a bi-directional interdependence with headquarters: not only receiving inputs from headquarters in terms of products or technology, but also providing information back to headquarters. This profile of interdependence is expected in multinational firms with headquarters managing the critical resources, competence and finance centrally. *Dominant Star* is a type of sub-units characterized by a moderate degree of interdependence, which is a unidirectional influence directed from it to others, such as other sub-units and headquarters. This profile of interdependence is expected in sub-units owning a particular competence or skill that contribute to the global competitive advantage of the entire multinational firms. In order to leverage the benefit of this competence or skill, this type of sub-units has to share their specific contribution with others, including headquarters. *Constellation Star* is a type of sub-units characterized by a high degree of interdependence, which is multidirectional and has a broad scope. This profile of interdependence is expected in multinational firms with network model (Bartlett and Ghoshal, 1989). Such organizations are often structured as a network with many interconnected nodes having similar significance and no obvious centrality.

Typologies of global R&D configuration

In the precedent part, we provide a brief literature review concerning organizational theories, subjects that help explain how the R&D activities are geographically distributed and effectively integrated taking their organizational structures into consideration. In this part, we systematically review the most important studies that have tried to construct typologies of global R&D configuration by defining the specialization of R&D units and their interdependence (Table 1). Some of these studies are explicitly presented as attempts at constructing typologies of global R&D configuration, while others focus on investigating the main role of each R&D units in MNCs. Three important conclusions can be drawn from this tabularization.

First, there are substantial differences in various typologies proposed by different authors. We find that terminologies, research samples, and research methods are very different when

comparing previous studies. In the literature, lack of conceptual integration is evident. We are easily confused by the different studies. We can't figure out the terms which are defined by different ways in different studies of typology. Very few studies in the field of R&D globalization have tried to derive a comprehensive typology of global R&D configurations.

Second, we observe that there is a reasonable convergence in the basic characteristics of the categories distinguished by the authors. We find that most of the terminologies and typologies suggested in previous studies can be differentiated with regard to their degree of functional specialization, geographic specialization and their distinct profile of interdependence.

Third, some specific reasons for establishing a R&D unit abroad also exist in industry and literature. For instance, "politically motivated" R&D units are established for certain political reasons. Country government might ask MNCs to conduct R&D activity in the country as a condition for being given access to its markets (Hakanson & Nobel, 1993). The "political motive" as one of institutional factors, has attracted several scholars' attention, which also verifies De Meyer (1993)'s justification about influences of institutional factors on R&D configuration. However, the "politically motivated units" are not reflected in this study, since we didn't find adequate evidences in the literature to prove that the political factor is one of the main determinants of R&D distribution.

Hypothesized Patterns of Global R&D Configuration

In this section, we define the hypothesized patterns of global R&D configuration. Distributed R&D units can be categorized by their distinct profiles of interdependence: lone star, passive star, dominant star and constellation star. According to the functional specialization, distributed R&D units can be defined as industrial research and product development. Last, by geographic specialization, there are three types of location: domestic, multi-domestic, and global distributed. By manipulating and combing these determinants, we find four possible archetypical patterns of global R&D configuration (Satellite Network, Upgrade Satellite Network, Loosely-coupled Network and Integrated Network) presented in Figure 1.

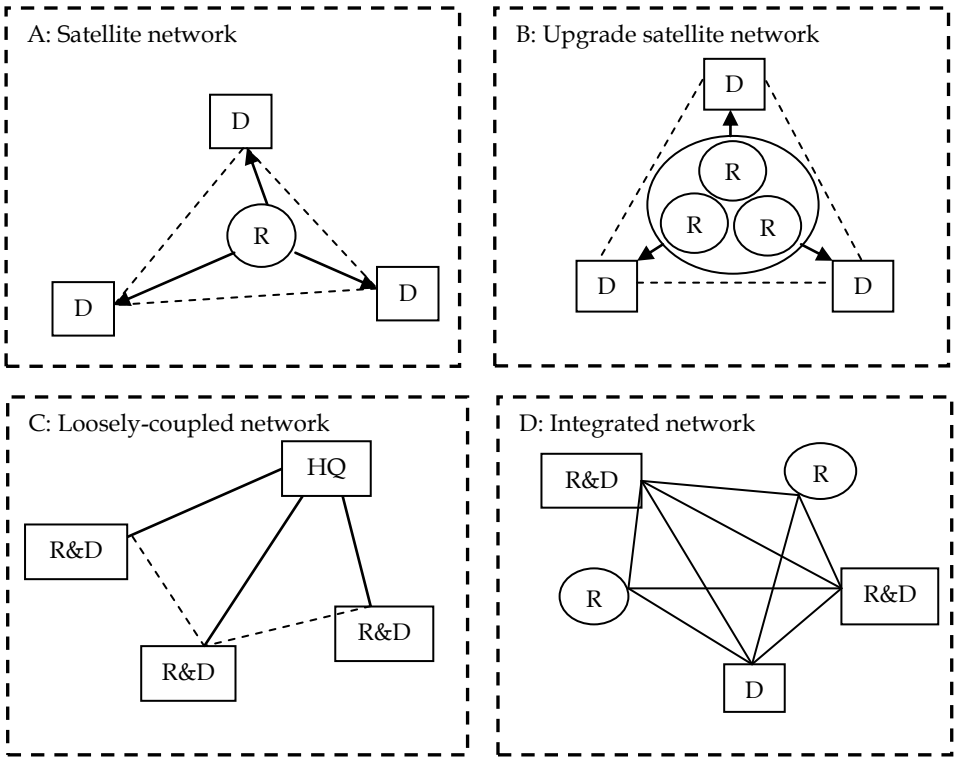

Figure 1: Hypothesized archetypical patterns of global R&D configuration

Satellite Network

In market-driven firms, product development activities are dispersed in a global scope, while industrial research on the core technology is kept in home country; in technology driven firms, research centers locate in knowledge-intensive regions and clusters, while product development is centralized in home country (von Zedtwitz and Gassmann, 2002). In these two cases, firms require strong capabilities on knowledge transferring and sharing, to fully utilize the advantages of the dispersed research units or the dispersed product development units (Kuemmerle, 1997). In this study, we call it "Satellite Network", since strong connections between the dispersed units and headquarters are required, for managing knowledge transfer from centralized research units to dispersed development units or from dispersed research units to centralized product development units. Among the four principle profiles of interdependences at subsidiaries of MNCs, "passive star" can reflect the interdependence profile of R&D units in a satellite network appropriately.

According to the literature in the field of R&D globalization (presented in Table1), we observe that the distribution of product development units, local product adaptation units, or manufactory support laboratories has been put forward much earlier than the distribution

of research units. In this study, the satellite network mainly refers to a model in which product development activities are highly dispersed in a global scope, while industrial research on core technologies is kept at headquarters research center. This study ignores the possibility that all product development activities are kept at home country. Configuration with distributed research centers is considered in the next model.

Upgrade Satellite Network

As above mentioned, in technology-driven R&D organization, research centers often locate in knowledge-intensive regions or clusters. Market sensitivity has been improved largely, as MNCs establish strong research collaboration with local research teams. Research on core technologies is often undertaken in a few research centers located in selected regions. Each dominant research center owns a particular competence or skill that strongly contributes to the global competitive advantage of the entire multinational firm. For reasons of knowledge efficiency and the high levels of interdependence between different research units, strong capabilities on knowledge transferring and sharing are required. Headquarters R&D centers not only manage the general direction of all research activities but also all basic standards for records and documentations. Among the four principle profiles of interdependences at subsidiaries of MNCs, "dominant star" can best describe the interdependence profile of R&D units in an upgrade satellite network.

Loosely-coupled Network

In the loosely-coupled network model, R&D activities are collocated within independent business divisions/subsidiaries in different regions. They are loosely-coupled together, since there are still certain interactions between different R&D centers which are often limited to general knowledge sharing. There isn't significant intra-organizational collaboration, considering the limited overlap among the research domains in different R&D centers. The role of headquarters R&D is limited to the reduction of overlap between different centers and corporate general strategy. Among the four principle profiles of interdependences at subsidiaries of MNCs, "lone star" interdependence profile best matches the characteristic of R&D units in a loosely-coupled network.

De Meyer (1989) implied that "when market proximity is critical or when external constraints are of prime consideration, companies tend to adopt the decentralized model". De Meyer's study (1993) demonstrated that (1) the main tasks of individual R&D center is

diversified; (2) a particularly strong domestic role of a certain R&D center at one location may exist; (3) in the case of "strong domestic role", the inter-link with other R&D centers may be not necessary. Birkinshaw (2002) explained a strong rationale behind the patterns of R&D configuration from knowledge perspective. In brief, the characteristics of the firm's knowledge assets (observability and mobility) affect the choice of individual R&D centers' structure (home-based, modular, or self-contained) and how the R&D centers are internally connected (loosely-coupled network or integrated network). Their study identified that in self-contained R&D centers and home-based R&D centers, knowledge assets are often low on mobility. The characteristics of knowledge assets could be one of the reasons why firms often adopt loosely-coupled network to manage the dispersed R&D centers.

Integrated Network

As Gassmann and von Zedtwitz (1999) had described the integration model scatters R&D throughout the enterprise. R&D organization is opened, allowing exchange of information across corporate and business units' boundaries. Although the corporate R&D may take on a key governance role, the governance role is secondary to the management of how to coordinate extensive corporate-wide R&D activities (Birkinshaw, 2002). There are two ways used to coordinate internally: team-based coordination and liaison-based coordination (DeSanctis, et al., 2002). In team-based coordination model, there are several technology teams and technology service teams that consist of team members from different business units and corporate R&D center; in liaison-based model, managers within corporate R&D center are given designated responsibility for linking central R&D at headquarters and the ones in different business units (DeSanctis, et al., 2002). In the integrated network model, the drivers of communication between two different research centers are likely to be one of collaborations or problem-solving. Among the four principle profiles of interdependences at subsidiaries of MNCs, "constellation star" interdependence profile best describe the characteristic of R&D units in an integrated network.

Research Method and Data

A mixed-method study approach that includes both quantitative and qualitative methods of data collection has been chosen for this study. In this empirical study, the primary source is archives of European Industrial Research Management Association (EIRMA) – an

accumulation of historical records of all R&D events organized during the period from 1973 to 2013. Another method selected for the qualitative study is the Focus Group. The Focus Group is an original and effective method which has not been widely used in academic literature on globalisation of R&D. EIRMA Archives and the Focus Group provide us an effective access to collect substantial evidences from industrial practices about how large multinationals configure their global R&D activities, and therefore helps us shape and conceptualize the hypothesized patterns of R&D configuration. Based on the findings of the qualitative study, the hypothesized patterns of R&D configuration were systematically tested through a quantitative survey, as the last step of this study.

EIRMA Archives

EIRMA engages around 120 major companies which are based in over 20 countries. EIRMA enables and supports the transformation of R&D and innovation management by inviting senior R&D managers/executives as speakers to share their practices and critical knowledge. During the period from 1973 to 2013, EIRMA organized 266 R&D events, including:

- 11 Workshops (WS, 1988 – 2001)
- 73 Working Groups (WG, 1973 - 2005)
- 98 Representatives Round Tables (RRT, 2000 - 2013)
- 52 Special Interest Groups (SIG, 2002 - 2013)
- 13 EIRMA Annual Conferences (AC, 2001 – 2013)
- 11 Management Study Groups (MSG, 2003 - 2013)
- 6 Learning Groups (LG, 2005 – 2011)
- 2 Focus Groups (FG, 2010, 2012)

All original materials, in particular, the conference reports and more than 2000 presentations from industrial R&D managers/executives have been archived at EIRMA. EIRMA Archives is a private database with rich knowledge and experiences on effective global R&D and innovation management. EIRMA Archives as a primary source in this study provides us an effective access to collect substantial evidences from industrial practices about how large multinationals configure their global R&D activities, and therefore to shape and conceptualize the hypothesized patterns of global R&D configuration.

Focus Group & Field Study in Brazil

The initiation of the Focus Group benefits from the main lessons learned by the previous PhD candidate who has already successfully tested the methodology in the same framework (EIRMA/LATTS, 2007-2010). The main mission of this Focus Group is to identify the specificities of the globalised R&D environments and in particular explore issues on the management of the globally decentralized R&D facilities. In particular, we aim to shape and conceptualize the hypothesized patterns of global R&D configuration with R&D experiences of participants in the periodical group meetings and field study.

The Focus Group is a group of R&D managers from 11 large MNCs (Table 2). The whole programme of the Focus Group includes 6 one-day group meeting in Paris, France and a one-week field study in Sao Paulo and Rio de Janeiro, Brazil. Brazil as focal country of the field study was decided by 120 EIRMA member companies together through an internal survey with a questionnaire. Several companies according to EIRMA claim that establishment of a new R&D center in Brazil has been involved in their corporate strategic plan for the next few year. However, only few EIRMA members companies (e.g. Siemens) had accumulated some managerial experiences from their Brazil R&D centers.

During the field study, I as a reporter working within the Focus Group attended 10 panel interviews between the Focus Group members and R&D managers/directors from large MNCs, Brazilian large innovative firms, Brazil National Laboratory/Universities and Governmental Funding Agent (Table 3). The content of each interview was structured according a questionnaire prepared by the Focus Group members in advance. The questionnaire mainly served to identify their R&D globalization strategy at corporate level and at subsidiary level, R&D organization structure, the main roles of R&D headquarters and distributed R&D units, mechanism of control, knowledge transfer, and expatriation.

IBM, GE and Siemens were chosen as representatives of well-established multinationals from developed countries by the Focus Group. Embraer, Petrobras and Natura were selected as representatives of the emerging challengers by the Focus Group, referring a well-known published report "**Global Challengers**" prepared by the Boston Consulting Group, which ranks the top 100 "challengers" from emerging countries on the basis of their performance and perspectives of rapid international growth.

Survey

After the conceptualization in the above-mentioned qualitative study, at the last step of this study, the hypothesized patterns of global R&D configuration need to be tested through a quantitative survey. In January of 2013, EIRMA initiated a programme "2013 Representatives Round Table" which aims to explore the complexity of establishing and managing research centers globally. The subject of this event - "localization and complexity of global labs" - attracted 30 senior R&D managers/directors' attention and interest. Most participants of this event worked in R&D department and they were involved in a decision-making process regarding research organization design, activities management and technology strategy.

In this conference, the Focus Group was offered an opportunity to discuss their findings about global R&D configuration with all 30 participants. Meanwhile, participants were invited to present the global R&D configuration in their firms. Based on the presentations and discussions, all participants were invited to complete a questionnaire about the patterns of R&D configuration and the evolution. Senior managers/executives responsible for controlling the entire R&D organization from 13 large MNCs filled the questionnaire completely (Table 4).

It is important to note that there are always some differences on the way of expression and cognitive gaps between academic knowledge and industrial practices. In the survey, participants were asked to select one or two models from the hypothesized patterns of R&D configuration that best reflect their current R&D organization. Meanwhile, they were asked to select one or two models which were prevailing at their R&D configuration five years before, and which reflect the optimal R&D configuration they expect in the future. Meanwhile, they were offered the possibility to design their own present relevant model if they could not find an appropriate model from the hypothesized configuration patterns we suggested. By comparing current configuration pattern to its past one and the anticipated one, the evolution of R&D organization can be presented.

Study Results and Discussion

In this study, we explore the patterns of R&D configuration in MNCs and the evolution. In particular, we investigate whether there is or not an entirely new pattern beyond the scope of

the existing literature. We also focus on dynamics: does the R&D configuration evolve from one pattern to another and how? Three important findings can be drawn from the field study and the survey.

(1), the hypothesized patterns of R&D configuration are systematically examined by the survey. The result of the survey conforms to the hypotheses. All firms that participated in this survey found a corresponding pattern from the four archetypical patterns. Respondents indicate a significantly high agreement with the four archetypical configuration patterns hypothesized in the survey. No respondent had difficulty to find an appropriate configuration model for their R&D organization. No respondent contributed extra features to the hypothesized patterns. The survey results for the four archetypical configuration patterns are very average. We did not identify a "prevailing" or "outdated" pattern from the four archetypical configuration patterns in this study.

(2), by the survey, we observe that in the last five years there has been extensive dispute over the organizational evolution (Figure 2). In the period from 2008 to 2013, the trend towards the Integrated Network is not evident. The evolutions from Satellite Network to Upgrade Satellite Network, from Satellite Network to Loosely-coupled Network, from Satellite Network to Integrated Network, all exist in the sample firms of this study. This result is not consistent with the findings in the literature. Gassmann and von Zedtwitz (1999) indicated that many companies with centralized R&D are adapting to their international environment. In particular, they identified a trend towards the integrated R&D network. DeSanctis, et al. (2002) also identified an evolution from a purest "decentralized model" to "global integration model" which scatters R&D throughout the enterprise. In this study, we find that the organizational evolution is diversified in R&D.

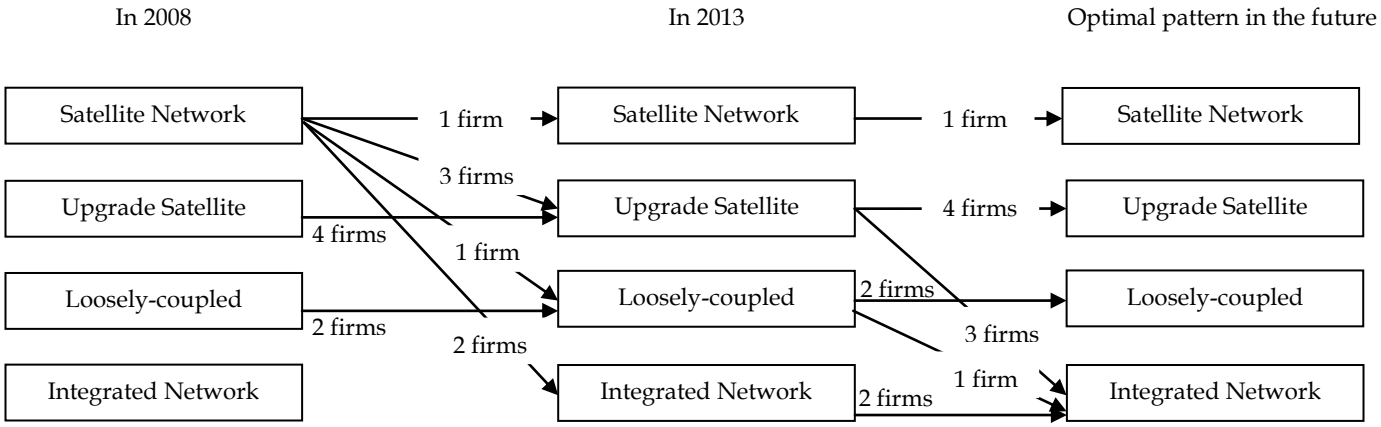

Figure 2: study results – organizational evolution in R&D

In the literature, several studies indicate that conventional organization is inadequate for the requirements of modern global R&D. For instance, the concepts such as "multi-domestic" or "polycentric" were proposed and often used in 1970s and 1980s when large firms just started to decentralize their R&D close to their corresponding business divisions and market. These models have been considered as "dying model" in the literature, due to the disadvantages, such as the redundant development, barriers of coordination, and high management cost. Gassmann and von Zedtwitz (2002) suggested that M&A activities may be the reason why some firms exhibit a polycentric R&D structure; M&A as a pattern of internationalization have been widely adopted by MNCs, however the synergy potential in R&D reorganization after the M&A activities was often not exploited well. Corporate Inertia was also used to explain why there is still certain persistence of home bias for important R&D at some firms (Cohen, et al., 2009). However, in this study, we identify that Loosely-coupled Network exists in several of very successful MNCs. In the survey, several senior managers clearly indicated that Loosely-coupled Network is the optimal organization model for their R&D.

Although over the last five years, organizational evolution towards Integrated Network is not evident, Integrated Network was selected as the optimal pattern for configuring global R&D by some firms in this survey. For instance, Air Liquide has already configured their global R&D activities by the Integrated Network pattern. In the survey, Integrated Network was selected by Air Liquide as the optimal R&D configuration pattern for the future. Specifically, Air Liquide organizes their R&D through more than 100 academic and national lab partnerships and a structure of nice Programs carried out in nine Core Global labs in R&D centers in Asia, Europe and USA (EIRMA RRT, 2013). Air Liquide split the work into "what" the company ought to be doing being, the focus of the Program Directors, and "how" it should achieve that, the responsibility of the Core Global Lab Directors, based on the management of technical competences. This method could avoid the negative effects of some situations in reality. Such as, some innovation centers do day-to-day support work, some research groups are based on sites that don't have production facilities and thus don't benefit from being close to key processes. However, five years before, Air Liquide's R&D used to be arranged by 18 domains of expertise, such as air separation, modeling, analysis and combustion etc, each headed by a domain director.

(3), although we did not find any entirely new pattern of R&D configuration in this study, we observe that different archetypical patterns are often mixed in large MNCs. The overall

configuration pattern at corporate level may be re-shaped when it will be implemented in certain host country or business units.

In the field study, all members of the Focus Group reached a consensus on an overarching strategy - "local for local". All three multinational companies (Siemens, GE and IBM) the Focus Group visited in Brazil have strong motivations to participate in the development of the country. The motivation of "solving Brazilian problems" has been expressed in their mission statement explicitly. According to the general manager of IBM Brazil Research Center (ex-general manager of IBM India Research Center), the main objective of R&D center in India is to contribute to global innovation competences of the whole firm. However, IBM's strategy for Brazil Research Center is different with the strategy for India Research Center. IBM establishes a new Research Center in Brazil for solving Brazilian problems. The general manager of GE Brazil Research Center replied a similar answer when he was asked to compare GE R&D globalization strategy for Brazil and India.

In Brazil, high local demands require firms to enhance their connections with local customers, suppliers, universities, and the government, etc. Their connections with headquarters mainly focus on general R&D strategy. In the field study, we observe that the country-specific mindset of "self-developed innovation", the richness of raw materials, and the large internal market, together give "loosely-coupled" and "domestic" characteristic to the global R&D configuration. However, in India, their global innovation strategy gives an "upgrade satellite" characteristic to the global R&D configuration.

Furthermore, compared with GE R&D Brazil and IBM R&D Brazil, Siemens R&D Brazil appeared to be rather independent – they are given more autonomy to manage their own technology, skill sets and competences. One of the essential historical reasons for this is that Siemens' labs in Brazil have a long-standing tradition and were created by the management of its Brazilian subsidiary following their own entrepreneurial initiative.

Thus, in this study we assume a mixture of Loosely-coupled Network and Upgrade Satellite Network exists in large R&D organization. By comparing the cases the Focus Group investigated in India and Brazil, we assume that the mixture of different configuration patterns may vary across the countries. The mixture of different configuration patterns may vary across the business units as well. R&D director from Unilever indicated that Food business units and People Care business units are organized extremely differently.

Comparing with the strategy at People Care Business unit, at Food business units, the distributed R&D centers focus more on product adaptation, rather than fundamental research.

Conclusion

Overall, R&D configuration as a key part of corporate resource configuration at MNCs is becoming much more critical and complex than ever before. This study aims to derive and test a new typology of R&D configuration patterns. The new typology includes four archetypical patterns of R&D configuration: Satellite Network, Upgrade Satellite Network, Loosely-coupled Network, and Integrated Network. Meanwhile, this study proves that in the last five years there has been extensive dispute over the organizational evolution. We find that the organizational evolution in R&D is diversified. The trend towards the integrated R&D network isn't evident. This result is not consistent with the finding in the literature.

Although we didn't find any entirely new pattern of R&D configuration in this study, we observe that different archetypical patterns are often mixed in large MNCs. The mixture of different configuration patterns may vary across the host countries and business units. Along with the fast confusion of R&D globalization and emerging of new R&D destinations, R&D configuration patterns need to be further shaped. This brings more managerial challenges for R&D managers at MNCs. Managers can learn how the different distributed R&D units could be managed with an effective manner from academic concepts. However, for R&D managers, it is critical to find an appropriate configuration pattern by further shaping or mixing the existing patterns, rather than following academic hypotheses.

Table 1: An overview of typologies of R&D configuration in MNCs

Authors	Empirical/ Conceptual	Study sample	Satellite network	Upgrade satellite network	Loosely-coupled network	Integrated network
Cordell (1973)	Empirical		Laboratories support	International interdependent laboratories, focusing on basic Research		
Ronstadt (1977, 1978)	Empirical	7 American multinationals, with 42 R&D units	Transfer Technology Units; Global Technology Units;	Corporate Technology Units	Indigenous Technology Units	
Behrman & Fischer (1980)	Empirical		R&D in home market firms; Local development (in host market firms)	Global Research units (in world market firms)		
Hewitt (1980)	Empirical		Product / process adaptive R&D	Global original R&D	Local original R&D	
Hood & Young (1982)	Empirical		Support laboratory	International interdependent laboratory	Locally integrated laboratory	
Porter (1986)	Conceptual			R&D in global industry	R&D in multidomestic industry	
Bartlett & Ghoshal (1990)	Conceptual				R&D in multidomestic industry	
Pearce and Singh (1992)	Empirical	163 mainly European and north American MNCs selected from Fortune 500	Support laboratory	International interdependent laboratory	Locally integrated laboratory	
Hakanson & Nobel (1993)	Empirical	20 largest firms from Sweden and their 151 technology units	Production support units; Market Proximity units	Monitor Research Units (do R&D, with strong global responsibility)		
De Meyer (1989, 1993)	Empirical	7 European firms and 15 Japanese companies		International R&D network for learning	Host location specific R&D	
Nicholson (1994)	Empirical	A study of 3M how to management its global network	Technical service; Regional product development centers		Regional technology centers	

Medcof (1997)	Literature review		factory support/local development	International Research; International market	Local Research	
Kuemmerle (1997)	Empirical & quantitative	238 foreign R&D sites	Home-base exploitation	Home-base augmentation		
Gassmann & von Zedtwitz (1999)	Empirical & terminology	33 companies	Ethnocentric centralized R&D; Geocentric centralized R&D	R&D hub model	Polycentric decentralized R&D	Integrated R&D network
Chiesa (2000)	Empirical	12 multinationals from EU, Japan, North America		Specialization-based structure		Integration-based structure
Birkinshaw (2002)	Empirical, quantitative	A group of large Swedish firms			Loosely-coupled	Integrated
Gassmann & von Zedtwitz (2002)	Empirical & terminology	290 research interviews and database research in 81 technology-intensive MNCs	National treasure R&D; Market-driven R&D	Technology-driven R&D		Global R&D
DeSanctis, et al. (2002)	Empirical	14 companies' organizational design for R&D		Networked;	Decentralized	Integrated;
Li & Yue (2005)	Empirical	378 international R&D centers and alliances in China	Concentrated R&D; Dispersed "D" and concentrated "R";	Dispersed "R and" concentrated "D"		Dispersed R&D
Criscuolo & Narula (2007)	Empirical			Multi-hub structure		
Cohen et al. (2009)	Empirical	Large firms in automobiles and wireless telecommunication industry	Centralization of R&D at home			

Table 2: An overview of experience background of core Focus Group members

Member	Job title	Company	Home country	Industry Sector
1	Senior International Expert	Airliquide	United States	Engineering
2	Technology Specialist	Airliquide	France	Engineering
3	R&D Manager	Arcelik AS	Turkey	Home applications manufacturing
4	Senior Scientist	DSM	Netherlands	Bio-materials
5	Vice-President in Open innovation	DSM	Netherlands	Bio-materials
6	Head of Department	Fraunhofer	Germany	Knowledge transfer
7	Head of international cooperation	Fraunhofer	Germany	Knowledge transfer
8	R&D group leader	Lafarge	France	Construction
9	Previous R&D director	Siemens	Germany	Engineering
10	Group Technology Development	SKF	Sweden	Engineering
11	Latin America Platform Manager	SKF	Brazil	Engineering
12	Director of International Cooperation	TuTech	Germany	Knowledge transfer
13	VP & GM	Umicore	Brazil	Engineering
14	R&D Director	Unilever	Netherlands	Fast-consuming
15	Business Development Specialist	VTT	Finland	Technology solution

Table 3: An overview of firms/organizations the Focus Group investigated during the field research in Brazil

Company name	Industry	Home country	Type
NATURA	Cosmetics	Brazil	local emerging challengers
Embraer	Air craft manufacturing	Brazil	local emerging challengers
Petrobras	Oil	Brazil	local emerging challengers
Siemens R&D Brazil	Engineering	Germany	Multinationals
GE Brazil Technology Center	Engineering	United States	Multinationals
IBM Research Brazil	Engineering	United States	Multinationals
INOVA Unicamp	Knowledge transfer	Brazil	Brazil national labs/universities
LNBio	Bio-tech	Brazil	Brazil national labs/universities
CTBE	Bio-fuel	Brazil	Brazil national labs/universities
FINEP	Innovation	Brazil	Government funding agent

Table 4: a brief introduction of the firms who participate in the survey and background of participants

Company	R&D strategy, organization, employees and its globalization	Title of Participants
ABB	Technology plays a key role for ABB. They have seven research centers, 7,500 scientists and 70 university collaborations across the world. At each of its 7 research centers around the world, scientists are working toward novel technological achievements that will help strengthen the 5 ABB Group divisions.	Group Leader, Corporate Research
GE	GE has approximately 36,000 technicians working across our business and global research centers at the intersection of technology and industry. GE Global Research is the hub of technology development for all of GE's businesses, with 10 global laboratories organized by scientific disciplines.	Managing Director Europe
IBM	IBM Research has 3,000 researchers in 9 labs worldwide. Each lab leads in selected domain, and collaborates closely with researchers worldwide, leveraging top scientists at each lab, aiming to integrate global research and also maximize the potential and identity of each lab.	Director and Vice President
Unilever	The R&D function at Unilever employs over 6,000 professionals located in 20 countries. The work of Research is to create proven breakthrough innovations which can then be developed further into fully formulated products. Research is carried out at six laboratories in the US, UK, Netherlands, India and China.	Vice President, R&D Foods Europe
AirLiquide	Air Liquide is the world leader in gases for industry, health and the environment, and is present in 80 countries with 43600 employees. Air Liquide R&D network is made of 8 research centers spread over 3 continents.	Deputy Vice President, R&D
VITO	As independent and customer-oriented research organization, VITO provides innovative technological solutions as well as scientifically based advice and support.	Unit Manager
Umicore	Umicore has more than 500 employees worldwide involved in research and development activities. R&D spending is 5% of revenues, excluding metal value. This puts Umicore at the top end of the league of chemical companies in terms of R&D intensity	Senior Vice President
Dupont	With expertise spanning two centuries, diverse industries and more than 90 countries, DuPont has brought world-class science and engineering to the global marketplace through innovative products, materials and services.	Manager, Corporate Research
Kemira	R&D is a critical enabler for organic growth in Kemira and provides differentiated capabilities on innovation. Kemira's R&D spending will be increased for the process improvement innovations.	Director, R&D
Outotec	To stay at the forefront of the industry, Outotec continuously develops its proprietary technologies and complements its in-house R&D with acquisitions and partnerships. Outotech has two R&D centers located in Finland and Germany.	Director, Technology Portfolio
Sika Tech	Sika AG, located in Baar, Switzerland, is a globally active specialty chemicals company. Worldwide local presence in 80 countries and some 15 200 employees link customers directly to Sika and guarantee the success of all partners.	Head of Corporate R&D
Michelin	One of the main thrusts of Michelin's strategy is to leverage technology and innovation to differentiate its products and services, so as to consolidate its leadership and effectively meet the needs of tire users.	Director, R&D
SKF	SKF has a strong global network of research and development (R&D) centers and laboratories, as well as established collaborations with major universities and research institutes, and the creation of new centers and collaborations is ongoing.	Director, Research Center

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