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*Strategic knowledge interactions within multinational companies.
An economic analysis*

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I dedicate this work to my grandmother Palmira.

List of Abbreviations

CoE(s)	Centre(s) of Excellence
Expats	Expatriates
FDI	Foreign Direct Investment(s)
FOC(s)	First Oder Condition(s)
HQ	Headquarter
MNC	Multinational Company
R&D	Research & Development
RJV(s)	Research Joint Venture(s)
Sub(s)	Subsidiary(-ies)

List of Variables

β_E	company external knowledge spillovers (e.g. from the industry)
β_I	company internal knowledge spillovers
$X_{A,B}$	effective knowledge investment of subsidiary A or B
$X_{a,b}$	effective knowledge investment of competitors in market A or B
$x_{A,B}$	subsidiary A or B own knowledge investment
x_H	HQ own knowledge investment
$\sum_{i=1}^{n_{A,B}} x_{a,b}$	knowledge investments of all competitors respectively in market A or B
$\gamma_{A,B}$	spillovers absorption rate the subsidiary's knowledge investment has on the market A or B
$\varphi_{A,B}$	complementarity between products (or production processes) in market A and B considering knowledge replication or application costs
$C_{A,B}$	cost functions of subsidiary A or B
$C_{a,b}$	cost functions of competitors in market A or B
$n_{A,B}$	number of competitors respectively in market A or B
$\Pi_{A,B}$	profits of subsidiary A or B
$\Pi_{a,b}$	profits of competitors respectively in market A and B

Vola solo chi osa farlo.

Louis Sepùlveda

Chapter 1

Introduction

“Omnes discere cupiunt artem oratoriam, sed nemo magistris vel rethoribus debitam dignamque laboris molestissimi mercedem vult solvere”¹

[Juvenales]

Thanks to the globalization process, which has invested the world economy in the last 40 years, firms have begun to evolve in order to respond to changed environmental conditions. The multinational company is nowadays a common organizational form. All the companies listed in the German stock exchange DAX 30 are multinational companies: they have a headquarter in the home country and several subsidiaries all over the world. Usually the strategic, administrative and personnel departments are located in the home country whereas production as well as research & development are to be found in the foreign market in order to respond quickly to market needs. The crucial feature of the multinational company is the ability to transfer knowledge from the unit owning it to those units, which can make best use of it. Moreover, some units has begun to distinguish themselves from other units due to the production, deployment and transfer of knowledge of use for the entire multinational company, the so called centres of excellence.

¹“Every one would like to own some knowledge, but only the few are willing to pay for it” (own translation).

1.1 Motivation of the work

Aim of the present work is that of shedding light on the structural and strategic knowledge interactions, which take place within the multinational company, within a theoretical economic model. This approach is quite new to the management and international business literature, which has mainly conducted empirical analysis in order to investigate the knowledge mechanisms underlying the multinational company.

For simplicity, the multinational company object of analysis has two subsidiaries. The headquarter, located in the home country and pursuing strategic as well as administrative tasks, has two subsidiaries in two different foreign markets. The multinational company involved in the model may produce goods as well as services.

Given the described organizational structure, the main research question leading the work may be subsumed as follows: should the headquarter involve the subsidiaries in the knowledge development processes or should this knowledge (defined as R&D) be carried out centrally? This question tries to subsume two streams of literature, that is to say, the management literature as well as the economic literature. The role played by headquarter and subsidiaries within the R&D activities will be investigated, taken into consideration both the external competitors in the two markets of reference as well as the company-internal information flows.

After having clarified the motivation of the work and the main research question, the next section is devoted to the clarification of the structure of the present work.

1.2 Structure of the work

The structure of the present work is the following: chapter 2 introduces the theoretical foundations of the multinational company in the strategic and international management literature. Particular focus is devoted first of all to the organizational structure of the multinational company and its evolution during the years (section 2.1). Secondly, the information processes to be recognized within the multinational company, how those infor-

mation flows depend on the structure of the firm and how they change accordingly (section 2.2) will be presented. Thirdly, the authority mechanisms that can be recognized within the multinational company and how they relate to the formal hierarchy will be debated in order to introduce the role of subsidiaries with strategic power, the so called centers of excellence (section 2.3). Finally, agency theory considerations are to be found as well (section 2.4).

The third chapter of the present work introduces the theoretical foundations of knowledge transfer and its impact on organizational structure within the economic literature. First of all, the structure of hierarchies will be briefly investigated (section 3.1). Secondly, information asymmetries and their implications in game-theoretical terms are introduced (section 3.2). Thirdly, the concept of authority is presented from an economic perspective (section 3.3). Chapter 3 concludes with the emerging of research joint ventures described as a recent organizational phenomenon that permits knowledge transfer within separated organizational entities (section 3.4).

The fourth chapter includes the main contribution of the present work, that is to say, the elaboration of a theoretical model for the analysis of the knowledge production (R&D) and diffusion processes within a multinational company with an headquarter and two subsidiaries located into two different markets. The role of the respective competitors will be taken into consideration as well.

Finally, the last chapter of the work (chapter 5) will discuss the main results of the model as well as the main theoretical and managerial implications. The limitations of the analysis and some recommendations for further research will be elucidated too.

Introduction	1. Motivation of the work and structure of the research
Theoretical Foundations	2. Investigation of the international management literature on multinational companies (historical evolution of the organizational structure, information flows, authority and power, elements of agency theory) 3. Investigation of the economic literature on knowledge transfer and organizational structure (hierarchies, information asymmetries, authority, research joint ventures)
Theoretical Analysis	4. Elaboration of a theoretical model with one HQ and two subsidiaries, analysis of the results for (1) decentralized, (2) centralized knowledge production as well as (3) HQ intervention within decentralized knowledge production
Conclusion	5. Discussion of the main results and of the contribution of the work, managerial and theoretical implications, limitations and recommendations for further research

Figure 1.1: Structure of the work and main contents (own representation)

Chapter 2

The Multinational Company: A review of the management literature

“ [...] Subsidiaries control heterogeneous stocks of knowledge and [...] competitive advantages can be achieved from orchestrating knowledge flows between MNC units in such a way that knowledge is transferred to those MNC units where it will increase value-added”

[Foss and Pedersen, 2002: 54]

The multinational company (MNC) is quite a recent organizational form, which originated in the last 40 years as a response to the internationalization of markets, of technology and of the value chain. The strategies underlying the internationalization process of a firm rely on the acquisition of new resources, the search of a new market and labor force, the increase of the firm knowledge-base, the quest for additional customers as well as the softening of the competitive environment. Firms decide to invest abroad according to three possible advantages they can gain out of this investment (Dunning, 1988: 2-6). First of all, an ownership advantage due to the access to technology or specific assets (structural ownership advantage) or due to diminished transaction costs (transactional ownership advantage). Secondly, a location advantage from the local resources, local labor force as well as from favorable local government policies. Finally, an internationalization advantage from the enhanced market position.

The actors involved in a multinational company are headquarter and abroad subsidiaries (Ghoshal and Bartlett, 1990). Subsidiaries compose the span of control of the

headquarter, which is generally thought to be the principal in a principal-agent relationship (Mudambi and Navarra, 2004: 388). Multinational companies forms evolve during the years as well, moving from a centralized organizational form, where the headquarter was controlling the subsidiaries abroad from the home-country (ethnocentric firm) to a network-like one (transnational firm), where both headquarter and abroad subsidiaries are embedded in an environment of interdependent exchanges with each other as well as with external partners.

The structure of this chapter is the following: first of all, the organizational structure of the multinational company will be introduced, referring also to the historical changes and evolutions occurred during the years due to changed environmental conditions. Secondly, information distribution mechanisms within the multinational company will be debated, focusing on the knowledge flows and knowledge transfer mechanisms taking place among the actors involved. Thirdly, the concept of authority within the multinational company will be analyzed from a management perspective in order to detect the peculiarities of control within the company. Finally, the last section will introduce the second chapter of the present work, quoting agency theory within the multinational company.

2.1 Organizational features and determinant organizational aspects

“[...] The multinational corporation is an economic organization that evolves from its national origins to spanning across borders”

[Kogut and Zander, 1993: 625]

The organizational structure of the multinational company was never static and represents nowadays a dynamic process influenced by changing environmental conditions and increasing actors involved. The internationalization strategies adopted for entering a foreign market play a crucial role influencing the organizational form as well.

2.1.1 Historical evolution of the organizational structure

Perlmutter (1969: 12) identified three main evolutions that characterized the multinational company. The first organizational structure could be observed mainly in US multinational firms. The so called *ethnocentric* structure allocated the power to the headquarter and tried to adopt home standards also to the subsidiaries abroad. That is why this structure was defined home-country oriented. Information flows were top-down, starting from the headquarter, which imposed the identification of the subsidiaries with the home country. The crucial problems arising from this first organizational structure came mostly from the absence of some feedback mechanisms with a related lack of innovation practices due to the high centralization. Also from a human resources perspective was the ethnocentric firm ineffective and inefficient since the best people left the subsidiaries. After the goal of reproducing and maintaining home standards abroad failed, the *polycentric* organizational structure characterized some multinational companies with its host-country orientation. The power was reallocated to the subsidiaries in order to foster local standards and react more promptly thanks to the information acquired on single markets features. Information flows were reduced to the minimum since local responsiveness did not need the transmission of information to the center. Therefore, no learning effects could be reached since the home-country knowledge was not exploited and the local knowledge was not replicated causing severe duplication costs. The successive stage defined by Perlmutter (1969: 13-14) mirrors the ultimate stage every multinational company should reach, that is to say, the *geocentric* world-oriented organizational structure. Power should be shared among headquarter and subsidiaries and information flows should be increased and widened in all directions. Global firm standards should be developed and deployed within the company such that the firm becomes international with focus on local interests as well. However, communication and travel costs may sometimes slow the decision making of the company.

A further typology and classification of multinational companies was provided by Ghoshal and Bartlett (1990). These authors considered the historical evolution of the multinational company as Perlmutter did. In the pre-war period in Europe the *multidomestic* firm was

the most common organizational form. It was a decentralized and loosely coupled organizational structure where the adaptation to local markets was the crucial peculiarity. Subsidiaries were given independence from the headquarter in order to enhance local responsiveness. Those decentralized units had decision making rights and responsibility. No control mechanisms were put in place by the headquarter and financial reporting was the only information flow occurring within the multidomestic company. This organizational form has some similarities to the polycentric host-country-oriented structure described by Perlmutter (1969)¹. During the 70s and 80s another organizational structure was to be recognized, especially in Japan. Contrasting to the decentralization of the previous years, the *global* firm was mainly centralized and focused on efficiency instead of on local responsiveness. The headquarter imposed its power and authority on subsidiaries, which were strictly controlled. Centralization was considered the optimal way to operational efficiency due to economies of scale and process standardization. Information was distributed top-down e.g. through expatriates². The peculiarities of the Perlmutter's ethnocentric firm are to be found³. The *international* firm represented the perfect combination of the previously described organizational structures. Born in the 50s and 60s in the US, this structure implied the centralization of some core competencies and the decentralization of other additional competencies. The international company based its value-added in the exploitation of best practices and in learning and knowledge transfer mechanisms. Resources and capabilities⁴ were employed and deployed within the company for growth.

Even though the international firm tried to combine the most competitive elements of the older organizational forms, it was not able to survive in the changing environment. Therefore, Ghoshal and Bartlett (1990) identified a new structure, which should resume the local adaptation and responsiveness of the multidomestic firm, the efficiency of the

¹See *supra*.

²For further information about the several roles played by expatriates within the multinational company please refer to section 2.4 of the present work.

³See *supra*.

⁴Resources and capabilities lie at the core of the resource-based view of the firm (Wernerfelt, 1984; Grant, 1991) according to which the recombination of internal resources may provide a source of competitive advantage.

global firm and the learning mechanisms of the international firm. The “transnational solution” is an integrated and interdependent network structure where the knowledge flows are fostered not only between headquarter and subsidiaries but also among subsidiaries themselves. Differentiation, coordination and interdependence should therefore arise within the company and represent the core organizational features. Subsidiaries are given the additional power of acting as strategic centers, the so called centres of excellence⁵ (Forsgren *et al.*, 2000: 45).

The transnational multinational company has all the features already identified by Gupta and Govindarajan (1991: 770), that is to say, it is “a network of capital, product, and knowledge transactions among units located in different countries”. Ghoshal and Bartlett (1990: 604) defined the multinational company “as a network of exchange relationships among different organizational units, including the headquarters and the different national subsidiaries that are collectively embedded in [...] a structured context”.

2.1.2 The role of internationalization strategies

The organizational structure adopted within the multinational company is also dependent on the internationalization mechanisms developed by a company for going abroad. Foreign direct investments (FDIs) occurs when a company invests abroad through the acquisition of an existing company or through the founding of a new business abroad. Both the acquisition and the founding strategy implies that the company going abroad has the management control over the abroad units. FDIs represent the last stage after exporting and licensing for expanding the business operations abroad⁶. The first action a firm can undertake in order to expand abroad is that of exporting. Exporting has generally speaking no significant

⁵Centres of excellence (CoEs) are those subsidiaries to which specific strategic tasks are assigned thanks to the capabilities they possess, replicate and develop which are of high value for the whole multinational company (Forsgren *et al.*, 2000: 45). Further aspects on CoEs will be treated in the next section 2.2.

⁶An additional definition of the three entry modes in a foreign market a company has at disposal is provided by Root (1987). The author adopted a different terminology for what concerns the licensing strategy, which is defined as "contractual entry mode", as well as for FDIs, which are referred to as the "investment entry mode".

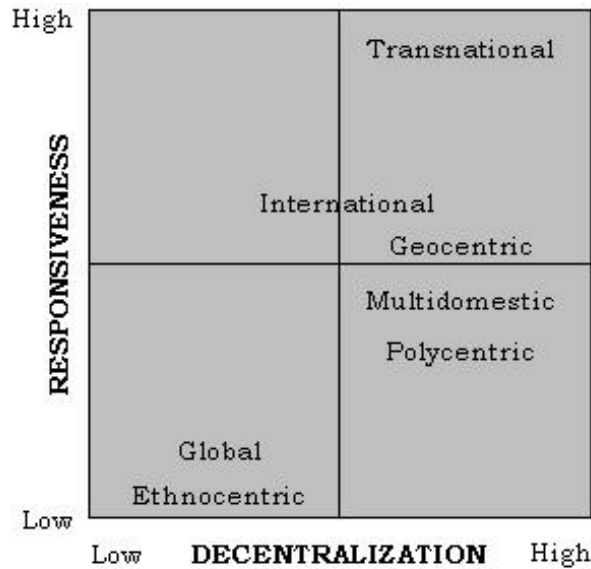


Figure 2-1: Historical evolution of the multinational company (own representation)

influence on the organizational structure of the company involved. It has the advantage of a home-country-based manufacturing combined with a precise choice of the markets to be reached abroad. No company-external local knowledge can be gained since the firm exporting its products or services is not interacting with the abroad environment, but simply locating its product/services in a favorable market. Another internationalization strategy, which is similar to exporting when considering the low impact on the organizational structure of the firm involved, is licensing. When selling a license to another firm, a company consents to the use e.g. of own patents, trademarks and copyrights. The investment involved is quite low, but the risk of creating a competitor connected to the impossibility to control quality and commitment represent some trade offs this strategy may have.

Contrasting to exporting and licensing, foreign direct investments have a crucial impact on the company organizational structure. Two main categories of FDIs can be observed: on the one hand, the acquisitions of an already established firm abroad. Acquisitions have increasingly become common during the last years since they permit the

buying not only of the infrastructure, but also of local and specific knowledge the target company has developed abroad. Among others, brand strength, existing relationships to customers, patents as well as established production processes can easily be acquired and more quickly compared to a home-company new establishment abroad. Moreover, the buying company could neutralize some competitors thanks to the better position covered in the abroad market due to the acquisition. Integration difficulties originating from divergent organizational cultures, increased complexity and absence of synergies may sometimes hinder the success of an acquisition abroad. On the other hand, a firm willing to go abroad has the possibility to invest green-field, that is to say, create an own subsidiary abroad. A green-field investment implies for the company involved the founding of a new business in a foreign country, which has not existed before. The time lag required for the establishment of a subsidiary abroad is quite a long one. The company has indeed the advantage of replicating the home-country organizational structure and standards but different regulatory regimes can slow the whole process and the different culture⁷ abroad may challenge the replication of home-standards or the establishing of new ones.

After having elucidated the several organizational changes, which occurred during the years within the multinational company, the impact the type of investment abroad has on the company structure has been mentioned as well. The next section 2.2 analyzes the information distribution within the multinational company.

⁷The concept of culture is quite a crucial one when referring to internationalization strategies and organizational structure. Hofstede (1984) and Namemwirth *et al.* (1987) defines culture as a “system of value and norms that are shared among a group of people and that when taken together constitute a design for living”. The basic elements of culture are social structure, language, communication, religion, values and attitudes (Hill, 2005: 93-108). Hofstede tried to relate culture and workplace in an international environment conducting a survey within the computer industry at IBM. He came to the so called “five dimensions”, which are respectively individualism vs. collectivism, masculinity vs. femininity, power distance, uncertainty orientation as well as long-term orientation. He realized that these dimensions differed according to the society to which the people involved in the survey belong. As a consequence, companies going green-field abroad can encounter some difficulties when trying to imposing their culture abroad. Culture differences should be considered within the internationalization stages and involved in the processes the company is willing to establish abroad. For further details on international expansion, organizational structure and culture please refer to Hastings, D. F. (May-June 1999). Lincoln Electric’s Harsh Lessons from International Expansion. *Harvard Business Review*.

2.2 Information distribution flows and knowledge sharing

The information distribution mechanisms that can be recognized within the multinational company changed during the years with the development of the organizational structure of the company, as has been already detailed debated in the previous section 2.1.

2.2.1 Information flows and organizational structure

The *multidomestic* firm was characterized from a complete absence of knowledge and information flows among the actors involved since knowledge was developed and retained within each independent unit. In the *global* firm core competencies were centralized and strategic knowledge was developed centrally. The information were transferred within the company on a need-to-know basis. Once the multinational company became *international*, top-down information flows took place. Even though a focus on the headquarter remained, knowledge was developed centrally but it was transferred later on to the subsidiaries. Within the *transnational* company vertical, top-down as well as bottom-up information flows were established in a worldwide network of exchanges. In this time the role of the headquarter changed substantially: from a provider and developer of centralized core competencies, which have been defined as “numeraire” in the traditional international business literature due to the fact that the flow of information from the headquarter to the subsidiaries is the most traditional one (Mudambi and Navarra, 2004: 390), the headquarter became an actor among the actors. Reversed knowledge flows, from the subsidiaries to the headquarter, gained importance. Additionally, the headquarter started to gain some benefits from these reversed knowledge flows e.g. “to fine-tune and coordinate a global strategy, improve processes in their own or other units in the network, or simply provide the missing link in the quest to develop a new product” (Ambos *et al.*, 2006: 296). An empirical research conducted by the three authors on a sample of 294 knowledge transfers of 66 overseas subsidiaries towards their 33 European headquarters reveals that knowledge coming from foreign subsidiaries is of high value for the receiving headquarters. The absorptive capac-

ity⁸ of the headquarter has also be mentioned as a critical variable in order to reach some benefits from the knowledge transfer.

During the years gained the subsidiaries some additional informal roles to their formal original roles. Subsidiaries were no more hierarchical units originated from a normative organizational solution, but they became also more complex due to the new functions they covered. Moreover, they increasingly received recognition within the whole company thanks to the company-crucial activities they simultaneously pursued. Strategic roles for knowledge development and deployment within the whole multinational company were given to the so called “centres of excellence” (Forsgren *et al.*, 2000: 45) once the multinational company internal organizational structure moved to a network-like. Therefore, it can be noted that the first organizational structures relied on the so called “liability of foreignness” and were based on knowledge-seeking measures for entering a new market (*internationalization model*⁹). Then, with the establishment of a wide company-internal and external network, the already existing information mechanisms became knowledge-generating and the roles within the company changed accordingly. The nature of these information mechanisms moved from a mere knowledge exploitation to a more complex and complete knowledge accumulation and dissemination within the whole company. Centres of excellence gain additional responsibilities since they are highly specialized in a specific field of action due to their skills and competences. A centre of excellence is per definition not only superior to other subsidiaries due to the strategic role it covers within the company thanks to its knowledge as a source of excellence with a consequent recognition within the whole company. In order to be considered as such, a centre of excellence should also provide knowledge, which is immediately used to other units of the multinational company.

⁸For the concept of absorptive capacity in the economic literature please refer to chapter 3 of the present work.

⁹For the purpose of the present work no entry strategies will be debated. For further information on the internationalization model please refer to Johanson *et al.* (1990).

2.2.2 Knowledge sharing and subsidiaries participation

When analyzing information distribution processes four main components should be taken into consideration. First of all, the sender of the information piece. Secondly, the receiver of the information sent. Thirdly, the information or competence itself that has been transferred. Finally, the nature of the relationship among sender and receiver could provide additional insights. Generally speaking, subsidiaries have been thought to be the actors with the most relevant and precious set of knowledge within the multinational company, that is to say, they can be considered as the sender of information. The information flow from the affiliate to the parent company has been defined by Mudambi and Navarra (2004: 389) as one of the four knowledge flows composing the knowledge creation process in the subsidiary and has been characterized per definition as “knowledge transfer”. Possible receivers are the headquarter, other subsidiaries as well as external partners like customers, suppliers, retailers, institutions. Knowledge flows taking place between the subsidiary and the previously cited company-external actors are the so called “spillovers” (Mudambi and Navarra, 2004: 389).

Gupta and Govindarajan (1991: 773-775) categorized the subsidiaries according to their participation to knowledge flows within the multinational company (the so called “magnitude of transactions”) as well as according to their role as receivers or providers of knowledge (the so called “directionality of transactions”) within the company network. They identified a framework in which the knowledge outflows (i.e. from the focal subsidiary to the overall company) and the knowledge inflows (i.e. from the company to the focal subsidiary) were crucial for the roles played by the subsidiary within the multinational company. The “global innovator” is the subsidiary providing knowledge to external company units. It has some similarities to the centres of excellence introduced some lines above¹⁰. On the contrary, the “local innovator” is that subsidiary having “almost complete local responsibility for the creation of relevant know-how in all the key local

¹⁰See *supra*.

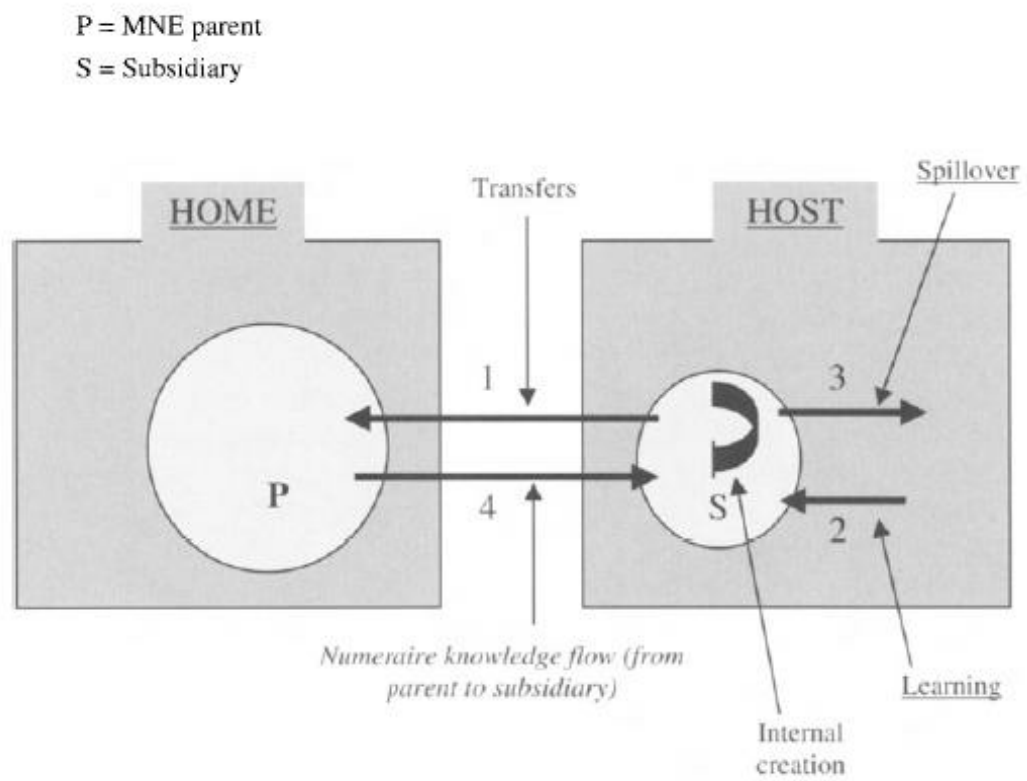
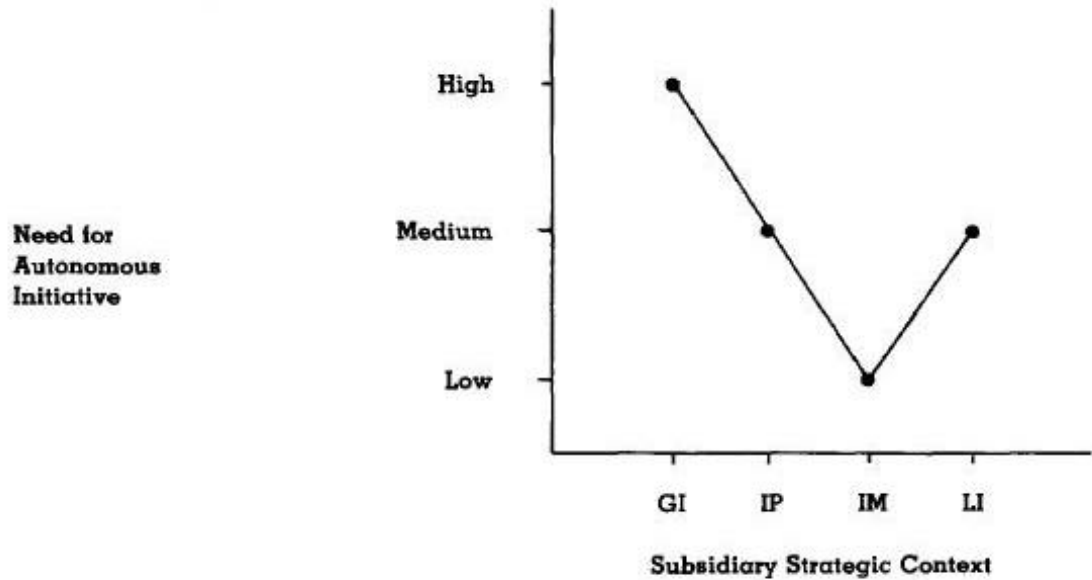


Figure 2.2: Knowledge flows within the multinational company (from Mudambi and Navarra, 2004: 389)

Subsidiary Strategic Context and Need for Autonomous Initiative



GI = Global Innovator, IP = Integrated Player, IM = Implementor, LI = Local Innovator

Hypothesized control mechanisms that need to be aligned to different levels of need for autonomous initiative subsidiary manager's locus of control, corporate-subsidiary decentralization, size of bonus relative to salary

Figure 2.3: Subsidiary categories according to their participation to knowledge flows (from Gupta and Govindarajan, 1991: 784)

functional areas" (1991: 775). The "integrated player" represents the subsidiary spreading non-autonomously knowledge within the company, that is to say, both knowledge outflows and inflows are considerably high. The last subsidiary category is that unit mostly receiving knowledge externally without playing an active role in developing it. This is the so called "implementor". The subsidiary participation to knowledge flows within the multinational company is strictly connected to the level of responsibility, authority as well as autonomous acting granted to it from the headquarter.

The additional information subsidiaries have at disposal is the so called "specific knowledge". This set of knowledge arise from "learning" (Mudambi and Navarra, 2004: 389),

that is to say, from the knowledge flows occurring from the external world to the subsidiary thanks to its embeddedness in the external environment¹¹. Specific knowledge is per definition that “knowledge that is costly to transfer among agents” (Jensen and Meckling, 1992: 1). Moreover, specific knowledge has all the features of tacit knowledge¹² since it is not only difficult to be transferred, but it is also not codified. The value-added subsidiaries have when creating, developing and exchanging knowledge derives also from the fact that their knowledge is content-specific and relation-specific and their absorptive capacity is embedded in the process itself (Björkman *et al.*, 2004: 444). Incentives are also to be considered within the knowledge transfer to other recipients since the subsidiaries have limited resources at disposal and they are not necessarily willing to invest them for external purposes not related to own concerns. Additionally, the transfer of core competencies to their units could reduce the competitive advantage the focal subsidiaries have (Björkman *et al.*, 2004: 445)¹³. This issue has been individuated also from Foss and Pedersen (2002: 53): “A basic organizational problem is to motivate the subsidiary to actually transfer knowledge that may be useful to other subsidiaries”. The authors mention the costs involved in the knowledge transfer as well as the compensation the subsidiary sending the knowledge would like to receive.

2.2.3 Knowledge management practices and obstacles to knowledge sharing

Information distribution mechanisms could be based on two main management strategies: the codification strategy and the personalization strategy (Hansen *et al.*, 1999: 106-

¹¹For further information on subsidiary embeddedness please refer to subsection 2.4 of the present work.

¹²The concept of tacit knowledge contrasts to the so called ‘explicit knowledge’, which is the codified knowledge of books and manuals that can be easily transferred and exchanged. Tacit knowledge is subjective, personal and originates from the experience of every single actor whereas explicit knowledge is objective, impersonal and quite easy to be shared and accumulated. For further information about explicit and tacit knowledge please refer to the work of Nonaka, I., Takeuchi, H. (1995). *The Knowledge-Creating Company*. Oxford University Press. According to the knowledge-based theory of the firm (Grant, 1996), knowledge is the most critical resource within the company and a source of sustainable competitive advantage. Tacit knowledge in the form of directions and routines is namely a barrier for competitors and a means of routines protection. In fact, tacit knowledge has the feature of casual ambiguity since competitors identify the overall success but are not able to discover the real success factors.

¹³Please refer additionally to the concept of subsidiary bargaining power of Mudambi and Navarra (2004: 388) treated in the next subsection 2.3 of the present work.

110). The codification strategy relies on the storing of explicit knowledge in form of electronic databases in order to ease the access to this knowledge from every member of the company. The codification and storing of knowledge should easily allow the dissemination and reuse of it. Codification “provides high-quality, reliable, and fast information-systems implementation by reusing codified knowledge” (Hansen *et al.* 1999: 109). On the contrary, the personalization strategy is more related to the single person, who is in charge of developing the knowledge. Information transfer takes place through direct interactions between people within a time-consuming network-like exchange process. Personalization “provides creative, analytically rigorous advice on high-level strategic problems by channeling individual expertise” (Hansen *et al.*, 1999: 109). The adoption of one of these strategies within the multinational companies does not exclude the other strategy, since the prevalent strategy is usually supported and implemented by the second one. Moreover, the quality and features of the information pieces involved in the transfer, that is to say, the nature of the knowledge involved, correlate with the strategy adopted.

The value-added the multinational company organizational structure could create is the allocation of knowledge from the unit originally creating it to the most efficient unit that can best use it. “[...] Subsidiaries control heterogeneous stocks of knowledge and [...] competitive advantages can be achieved from orchestrating knowledge flows between MNC units in such a way that knowledge is transferred to those MNC units where it will increase value-added” (Foss and Pedersen, 2002: 54). However, the multinational company faces a trade-off between the attempt of codifying the knowledge for transferring core competences within the company and the exposition to some additional risks due to imitation from competitors. Some obstacles that can be encountered when transferring knowledge is first of all the so called ‘subsidiary embeddedness’¹⁴, that is to say, the network of relationships a subsidiary is establishing with the external environment and which can create lock-in dynamics on the long run. Secondly, the specificity of the knowledge to be transferred due to the provision of customized solutions can hinder the transfer of the knowledge involved.

¹⁴For further information on subsidiary embeddedness please refer to next subsection 2.4.

Thirdly, the tacit component of knowledge, as has been already mentioned in the previous lines, is per definition one of the most crucial transfer hindering elements. Fourthly, the ‘not-invented-here’ syndrome could cause some attritions within the knowledge recipients due to the fact that the transferred knowledge was not directly produced within the unit receiving it. Moreover, existing company structures as well as the time component may not facilitate the deployment of knowledge within the whole company or the knowledge employment where it can best be used.

2.2.4 Sources of knowledge flows

After having debated the historical evolution of knowledge flows within the multinational company, the definition of information distribution mechanisms occurring within the company as well as the strategic role covered by subsidiaries according to their knowledge-related activities some strategies and problems when managing knowledge have been presented as well. The focus shifts now from the content of the knowledge flows to the source of these flows. Foss and Pedersen (2002) tried to investigate the relation between the sources of knowledge within the multinational company and the organizational structures required for a successful knowledge transfer. They individuated three main knowledge sources, i.e. knowledge internally developed, knowledge originated from network relations as well as knowledge from local clusters (Foss and Pedersen, 2002: 51). Internal knowledge is the knowledge that is “embodied in bundles of routines of a highly tacit and social nature” (Foss and Pedersen, 2002: 55-56). Internal knowledge is the most easy knowledge form to be transferred among the three typologies since it is based on already transferred knowledge within the multinational company “through existing transmission channels”. The authors come to this conclusion throughout a sample investigation of 2107 subsidiaries from seven countries located in the North of Europe. The headquarter has a detailed understanding of internal knowledge and the receiving units have quite a high absorptive capacity. Internal knowledge reflects the strategic choices, which have been taken within the multinational company due to the “pattern of specialization in the accumulation in certain types of

knowledge within the MNC” (Foss and Pedersen, 2002: 58). Interdependence within the units is a requirement of successful transfer of internally accumulated knowledge.

Network-based knowledge is the external knowledge originating “from long-lasting interaction with specific external parties, notably customers or suppliers” (Foss and Pedersen, 2002: 55-56). It originated as a solution to specific problems or needs of external local counterparts and it has therefore a substantial tacit component. It is less easily transferable than internally accumulated knowledge and the most common target units are those similar to the sending one. It involves non-routine, close and intensive communication mechanisms, e.g. in terms of sending of people to the receiving unit for a limited amount of time. As already mentioned some lines above, network-based knowledge is coupled to needs of external parties and it may therefore be object of further modifications. However, the research hypothesis implying that the knowledge transfer may be fostered by intra-company trade like the exchange of goods and services is not supported by the data collected by the authors among 2107 subsidiaries. (Foss and Pedersen, 2002: 64).

Cluster-based knowledge is that “knowledge controlled by the subsidiary that to a substantial extent is based upon knowledge inputs from e.g. a well-educated work force or local knowledge institutions” (*ibidem*). It is the least transferred knowledge since it is of “no or little use for other MNC units” (Foss and Pedersen, 2002: 57). Cluster-based knowledge has been proved to be more successfully transferred to other multinational company units if the sending unit enjoys a degree of autonomy¹⁵.

The new contribution of the authors to the literature relies in the direct relation between knowledge sources and organization structures (interdependence, intra-firm trade as well as autonomy) as facilitators to knowledge transfer they draw, as outlined above. In fact, “knowledge with different characteristics needs different organizational mechanisms to facilitate the transfer of that knowledge” (Foss and Pedersen, 2002: 64). A crucial aspect underlined is also the “context specificity” of knowledge, that is to say, the interdependence

¹⁵For further details on autonomy as a power form originated from knowledge please refer to the next subsection 2.3.

between the knowledge developed and the context in which it is located. Context-specific knowledge has been identified as a hardly reusable knowledge within other units.

2.3 Authority and power

After having analyzed the evolution of knowledge flows within the multinational company, some obstacles to knowledge transferring have been introduced. The crucial role played by some subsidiaries in the replication of knowledge has been historically debated as well. Purpose of the present subsection is shedding light on authority within the multinational company. Since the actors involved, that is to say headquarter and subsidiaries, belong to two different organizational levels a dual perspective will be adopted in order to cover all the peculiarities of authority.

“MNCs can be considered to be dispersed structures of power in which the top management’s authority does not necessarily result in hierarchical power being the ultimate control mechanism” (Andersson *et al.*, 2007: 802). The concept of authority is quite a crucial one within the multinational company. Due to the fact that the interests of the headquarter and the interests of the subsidiaries may be divergent and are not always aligned the actor having power and decision rights could more easily enable the implementation of the desired projects or actions. An interesting interpretation of these issues is given by the so called “federative multinational company” (Andersson *et al.*, 2007), where the headquarter struggles for the control of the abroad subsidiaries and the subsidiaries themselves, on the contrary, fight for their independence in a complex and interrelated network without any defined hierarchical roles. Subsidiary power in the federative multinational company has been defined as “the sub-unit’s ability to avoid the control that headquarter wishes to impose” (Andersson *et al.*, 2007: 803-804). Control avoidance may be put in place by the subsidiaries in terms of central bureaucratic system obstruction, budget impact reduction as well as the pursuing of independent actions. An interesting point the authors referred to is that the struggle for power is not only an internal one, but it has overall consequences since the main purpose is to “influence the organization’s

overall strategic development” (*ibidem*).

2.3.1 Subsidiaries’ knowledge as a power source

The autonomy the headquarter spontaneously gives to its subsidiaries has been defined in the international business literature as “discretion” (Mudambi and Navarra, 2004: 399). However, it has been extensively debated that subsidiary themselves possess some autonomy, which originates from their “bargaining power” (Mudambi and Navarra, 2004: 399). The crucial feature of subsidiaries’ bargaining power is the fact the headquarter cannot easily revoke it because it is based on subsidiaries’ accumulated knowledge. The authors stated that “knowledge and knowledge-creating potential are [...] the key source of subsidiary bargaining power. Knowledge-intensive subsidiaries have strong bargaining power, and have greater ability to resist headquarters’ attempts to control their resources” (Mudambi and Navarra, 2004: 399)¹⁶. Gupta and Govindarajan (1991: 780-786) came to the same conclusions. After having individuated four main subsidiary typologies according to the knowledge inflows and outflows they display within the multinational company¹⁷, the authors realized that those subsidiaries having more responsibility in the company receive as a consequence an increased level of authority compared to the other subsidiaries. The same considerations holds for the conduction of “autonomous initiative” by the subsidiary. Birkinshaw *et al.* (1998: 224) identify a process of subsidiary activity thanks to the resources the subsidiary owns and develops. The access to specialized resources, which is fostered by the “visions and actions of subsidiary leadership”, increases the subsidiary initiative within the multinational company and enhances its international responsibilities. Hence, the subsidiary will enjoy an increased visibility within the whole company, strengthening its position and having more place for its strategic initiatives.

Foss and Pedersen (2002: 53) describe the so called “motivational problem” in terms of the willingness of a subsidiary to give up its bargaining power when engaging in

¹⁶For further insights on knowledge flows within the MNC please *see supra*.

¹⁷*See supra*, section 2.2.

knowledge transfer to other units within the multinational company. “A subsidiary that possesses a knowledge monopoly controls a lever of bargaining power in the MNC, since it controls a crucial complementary asset” (*ibidem*). When referring to the monopoly power a subsidiary may have within the multinational company thanks to its knowledge base the two authors identify two divergent organizational contexts: a static and a dynamic one. In a static organizational context a subsidiary that transfers its knowledge to other units will cover the same role of these units after the knowledge exchange and lose its monopoly power due to the transfer of its source of competitive advantage. On the contrary, in a dynamic environment subsidiaries gain power from engaging in knowledge transfer with other units since these repeated interactions increase their influence within the company as a whole.

Authority generally come from power. Andersson *et al.* (2007: 806) define power as the “ability to ‘win’ political fights in resistance to others in the organization”. Moreover, the subsidiaries’ access to critical resources for other subsidiaries or for the company as a whole has been identified as an additional power form together with competence development in other multinational company units. The network embeddedness of a specific subsidiary, that is to say, the multiple relationships with internal and external business partners also increase its power base¹⁸. Knowledge about those networks is the last element contributing to subsidiary power.

2.3.2 Subsidiaries’ embeddedness as a power source

The knowledge developed through long-lasting relationships with external parties has been defined as network-based knowledge. The knowledge deriving from external inputs is the so called cluster-based knowledge¹⁹. “If subsidiary knowledge is mainly based on external knowledge, it is hard for MNC headquarters and top management to direct the subsidiary’s acquisition of such knowledge in any detailed manner because of the knowledge asymmetry“

¹⁸For further details on information exchanges due to network embeddedness please refer to the previous section 2.2.

¹⁹*See supra.*

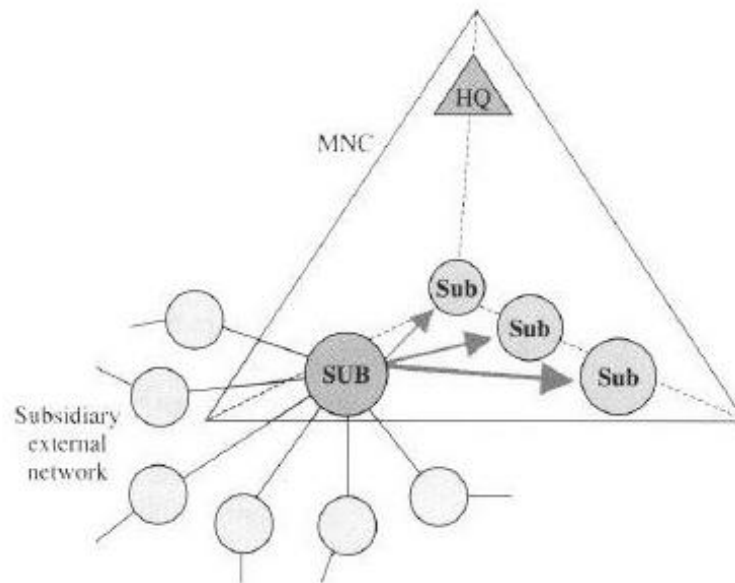


Figure 2.4: Subsidiaries' embeddedness as a power source (from Andersson *et al.*, 2002: 981)

(Foss and Pedersen, 2002: 58). In that case a subsidiary will be granted decision rights autonomy, which will have a positive impact for the multinational company as a whole, since “[...] more autonomy allows it to better tap into networks and local clusters and also means that more knowledge will be more successfully transferred to other MNC units” (*ibidem*). Hence, autonomy has been identified as a form of authority.

2.3.3 Specific advantages as a power source

An additional source of authority may be identified in those subsidiaries having the so called subsidiary-specific advantages. “Subsidiary-specific advantages reflect the competencies and capabilities that can be exploited globally” (Rugman and Verbeke, 2001: 244). They “combine the benefits of global exploitation of know-how with difficulty in its internal diffusion” (Rugman and Verbeke, 2001: 248). The drivers of those superior competencies and capabilities have been underlined by the authors within three main competence build-

ing patterns. First of all, the subsidiary is given autonomy when “engaging in ‘global market initiatives’ that should typically lead to global-scale efficiencies and higher local value added” (Rugman and Verbeke, 2001: 242). Secondly, the link the subsidiary has to the parent company before starting an internationally-relevant project is quite strong, that is to say, the internal support and recognition is crucial for permitting a subsidiary to act on a global scale. Thirdly, the global learning effects start from the local knowledge development. After the conditions for the existence of superior competencies have been elucidated, the authors elaborate a subsidiary-specific advantage development process. The contingent factors for this development are the following: the knowledge developed by the subsidiary is tacit and context-specific, such that mobility barriers hinder the internal knowledge transfer; the subsidiary displays a knowledge gap with other multinational company units due to its specific advantage; no negative externalities can be observed; finally, synergies should be reached thanks to the interdependence between the subsidiary-specific advantages and the whole company in order for those advantages to become firm-specific advantages (Rugman and Verbeke, 2001: 244-245). Therefore, the existence of subsidiary-specific advantages increase the autonomy the subsidiary has when searching for new projects and enhance its authority position within the multinational company thanks to the value added the subsidiary can contribute to the company.

Birkinshaw *et al.* (1998) investigate the contribution some subsidiaries can give to firm-specific advantages of the multinational company conducting a survey in 229 manufacturing subsidiaries of large multinational companies in Canada, Scotland and Sweden (Birkinshaw *et al.*, 1998: 229). They individuate a typology of subsidiaries that have some crucial and necessary characteristics for the development of firm-specific advantages: those subsidiaries have specialized resources²⁰, they are recognized within the whole company, and their competences are transferred and leveraged within other units of the multinational

²⁰ After having defined the subsidiary as “a heterogeneous bundle of resources” (Birkinshaw *et al.*, 1998: 224), the authors classify the resources into two main categories. Location-bound resources are those resources that are strictly interdependent with the location they have been developed in. Non-location bound resources are, on the contrary, those resources that can be applied, developed and redeployed within the entire multinational company since they are not uniquely related to their location.

company. Thanks to these peculiarities the role those subsidiaries play within the company has been identified as “contributory”. The authors tested the importance of the relationship between parent company and affiliates and come to the conclusion that “subsidiary autonomy, in particular, had an important influence on both initiative and contributory role” (Birkinshaw *et al.*, 1998: 235). Therefore, the authority given to the headquarter to those superior subsidiaries, which are able to reach firm-specific advantages, has proved to be beneficial to the whole multinational company.

Authority has been proved to be of substantial importance within the multinational company. Structurally and hierarchically, headquarters are supposed to have authority and decision rights, which are sometimes delegated from them to their abroad subsidiaries. However, some knowledge-intensive subsidiaries having access to specialized resources may be given some bargaining power and some additional autonomy, which cannot be easily revoked. Therefore, their strategic position within the multinational company is enhanced and their influence to the company overall strategy will be strong due to their contribution, e.g. in term of realization of some firm-specific advantages due to their subsidiary-specific advantages. The next section will go further into the authority relationship between headquarter and subsidiaries analyzing it from an agency theory perspective.

2.4 Agency theory and interests alignment

The concept of agency theory is based on the assumption that the interests of the actors involved in a relationship are not aligned. In the specific context of the multinational company subsidiaries may not always acting in accordance to the objectives set up by the headquarter. “An agency problem exists if subsidiary management makes decisions that are not congruent with those desired by headquarters due to goal incongruence between headquarter and the subsidiary and self-interested behaviour on the part of subsidiary management” (O’Donnel, 2000: 526). As has been pointed out by Birkinshaw *et al.* (1998: 222-223), the international business literature has tried to group the role played by the subsidiaries within the multinational company and with respect to the headquarter into

three main categories. First of all, the subsidiary has been located in its local environment and has been described as entity subject to “environmental determinism” due to its local responsiveness. Secondly, the subsidiary has been described as an agent of the headquarter due to its compliance to and pursuing of “head office assignments”. Finally, the subsidiary has been identified as an independent actor acting according to its own “subsidiary choice”. This last view on the subsidiary role bases “on the assumption that subsidiary management understand their local market and their local capability better than the head office” (*ibidem*). The requirements for existence of agency problems within the multinational company are therefore once again underlined.

2.4.1 Monitoring, incentives, and social control mechanisms

The mechanisms that are established within the multinational company in order to overcome agency problems are threefold: monitoring, incentives (Jensen and Meckling, 1976: 5-7) as well as social control mechanisms. The most widespread monitoring mechanisms within the multinational company are expatriates and bureaucratic mechanisms. These two measures should limit the information asymmetry between the parent company and its subsidiaries originated mostly from their geographical and psychic distance²¹. Expatriates are individuals coming from the headquarter situated in the home-country, who are sent for a limited amount of time to the subsidiaries abroad for absolving several tasks. First of all, they should control the foreign unit in order to solve agency problems. “Headquarters’ monitoring of subsidiary business networks is one important power-base of headquarters that may constrain subsidiary rent-seeking behavior, that is, influence on strategic decisions in the MNC” (Andersson *et al.*, 2007: 804). Moreover, they should absorb foreign competencies that can be of crucial use once they come back to the headquarter. The

²¹Psychic distance is defined as factors preventing or disturbing the flows of information between firm and market. Examples of these factors are differences in language, culture, political system, level of education, level of industrial development etc.” (Johanson *et al.*, 1975: 307-308). According to the psychic distance paradox, “starting the internationalization process by entering a country psychically close to home may result in poor performance and, possibly, failure. (O’Grady *et al.*, 1996: 310). In fact, “perceived similarity can cause decision makers to fail because they do not prepare for the differences” (*ibidem*).

nature of their international assignment is also connected to the organizational culture of the whole multinational company, which should be created or strengthened. In the international human resource management theory expatriates are defined as “carriers of culture in MNCs, tending to introduce in the affiliate some features of the parent country culture” (Rosenzweig and Nohria, 1994: 236). Personal development is a motivating factor as well. The presence of expatriates in the subsidiary is positively correlated with the adoption of human resource management home-country practices abroad (Rosenzweig and Nohria, 1994: 246). However, a study conducted by Björkman *et al.* (2004: 452) on a sample of 134 Finnish and Chinese subsidiaries concluded that “the use of expatriate managers is not significantly related to outward knowledge transfer from subsidiaries to other parts of the MNC”. Bureaucratic measures as rules and procedures are a well-adopted monitoring mechanism as well²².

In order to overcome outcome measurability and outcome uncertainty in the relation between the headquarter and the subsidiaries financial incentives in terms of salaries, bonuses and stock options have been widely adopted. Björkman *et al.* (2004) study the use of agency theory and socialization mechanisms for the purpose of knowledge transfers within

²²The numbers of expatriates sent abroad are nowadays still increasing. However, most of them are foreign-country nationals, who have been sent to the headquarter. Moreover, alternative forms of expatriates sending like commuter assignments and virtual assignment have become quite a widespread practice.

Covering the role of an expatriate has to deal also with the management of a lot of parties involved: the own headquarter, own superiors, local partners and local employees as well as the own family. Therefore, expatriates should fulfill some criteria in order to be selected for an assignment abroad. First of all, they should be technically competent and should be able to adapt to change. Secondly, they should be granted the support of their own family before being involved in the selection process. Thirdly, prospective expatriates should be open-minded, emotionally mature in order to deal with uncertainty, ambiguity and frustration. Finally, they should possess the required language skills for the target country.

The international resources management literature has individuated four main phases expatriates go through during their assignment abroad. At the very beginning, a sort of "honeymoon" status is to be recognized. Later on, a "culture shock" may arise due to the culture, environmental and job change. At this stage, frustration, anxiety as well as anger may negatively influence the assignment. After an "adjustment" period, expatriates approach the "mastery" phase, in which they master their assignment abroad.

Research on expatriates underlines that *ex post* repatriation practices are at least so crucial as *ex ante* expatriates practices. However, most companies lack right measures for the post-assignment phase. Accordingly, most expatriates feel that their re-entry position is not challenging enough and that they cannot make use of the acquired experience abroad. Moreover, they conclude that their abroad assignment had a negative impact on their career development at home. A considerable percentage of expatriates leave their company a few years after they returned back home.

the multinational company on a sample of 134 subsidiaries located in Finland and China. They discover that subsidiary management compensation criteria are not a necessary condition for granting knowledge transfer towards other units of the multinational company. On the contrary, “the higher the perceived importance attached to knowledge transfer by headquarters when evaluating the performance of the subsidiary, the more the knowledge transferred from the subsidiary to other corporate units” (Björkman *et al.*, 2004: 446). Therefore, performance evaluation criteria set up by the headquarter play a crucial role. Corporate socialization mechanisms, e.g. “international training programmes”, “international task forces and committees” as well as “visits across MNC units” positively contribute to the knowledge exchange as well.

With the evolution of the multinational company organizational structure into a network-like structure the outcome of one unit has become dependent from those of other units, decreasing the effectiveness of monitoring and incentive mechanisms. Therefore, social control mechanisms gained importance in the last years. “The aim of corporate socialisation is to establish a set of values, objectives, and beliefs across MNC units [...], providing them with a strong sense of a shared mission and a unitary corporate culture” (Björkman *et al.*, 2004: 447). The most common social control mechanisms are three: vertical integration, lateral integration and non-monetary incentives. The main purpose of vertical integration is that of creating a shared understanding within the multinational company, such that subsidiaries feel to be a part of the company. Assignments to the headquarter, special training and mentors are some practices for making them feel closer to the parent company. Lateral integration originated from the need to establish roles understanding once the multinational company became transnational. A self-sustaining and self-motivated network should arise through e.g. the establishment of transnational teams composed of individuals coming from the whole company for carrying out a project. Non-monetary incentives in terms of increased carrier possibilities and sense of belonging²³ are the last

²³Sense of belonging is one of the stages composing the hierarchy of needs developed by Maslow (1970) in order to study motivation and human personality also within organizations. The first stage of the hierarchy elaborated by the author covers the so called ‘physiological needs’, which are the basic ones every human

form of social control mechanism with the main aim of encouraging cooperation.

2.4.2 The external environment: embeddedness

Once the multinational company developed into a network of relationships between headquarter and subsidiaries, between subsidiaries with each other, and between the company with the external environment a mix of control mechanisms has been adopted since the formal ones, as already discussed within the previous lines, were no more effective. According to resource dependence theory a subsidiary is owning a resource, which is crucial for the entire multinational company and for the headquarter as well (Doz and Prahalad, 1991). According to business network theory, this resource can be embedded in the specific business relationships a subsidiary has with company-external actors and may hinder the control mechanisms put in place by the headquarter for aligning the subsidiary's interests to its own interests. Therefore, "any study of headquarter's control, to which a subsidiary is an object, has to consider this web of relationships" (Andersson and Forsgren., 1996: 488). The external relationships a subsidiary has within the external environment is the so called subsidiary embeddedness. "A subsidiary's embeddedness is defined as the total sum of interdependencies it has as a consequence of its position in a business network. The stronger the interdependence between the subsidiary and its counterparts, the higher the degree of embeddedness" (Andersson and Forsgren, 1996: 490). Within this network the subsidiary involved is not necessarily covering the same role it has been assigned within the multinational company: "its strategic identity in the network is assumed to be based on business relationships developed over a long time" (Andersson and Forsgren, 1996: 489).

being has, like food and water. Once these needs are satisfied, 'safety' or security is the next stage in the hierarchy. Family, property, employment are some examples of needs falling in this second category. 'Belonging' or love is at the third level of the Maslow's pyramid of needs and refers to the need for friendship or family. The further stage is 'esteem,' which locates the human being within a group giving to him/her respect or sense of achievement. The individual himself/herself has at this stage confidence, self-esteem and respect of others as well. When the previous needs are satisfied the last category can also be reached, that is to say, 'self-actualization'. For detailed information about the origin of this theory of needs, its position within the motivation theory and within organizational behavior research please refer to Buelens *et al.* (2006).

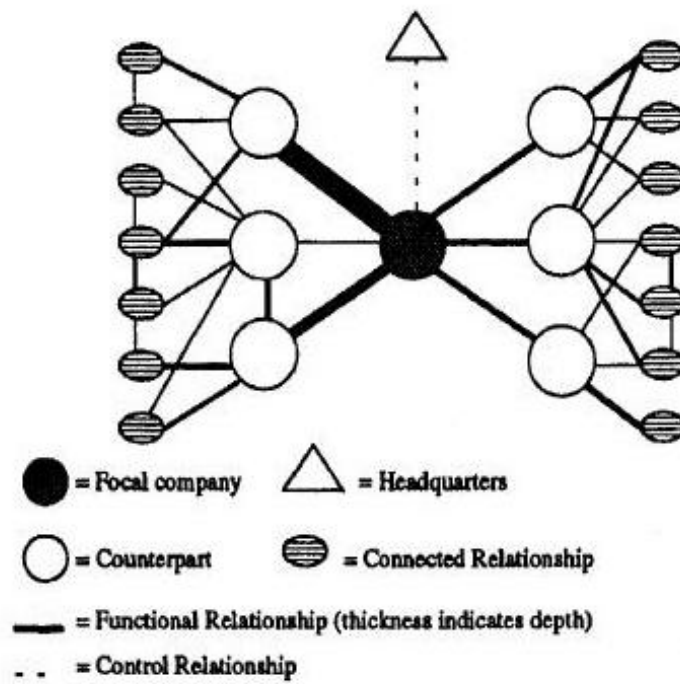


Figure 2·5: Subsidiaries' network embeddedness (from Andersson and Forsgren, 1996: 492).

Several kind of embeddedness have been recognized by Andersson *et al.* (2002) within the multinational company. “Relational embeddedness” occurring when the focal subsidiary can reach learning effects due to the additional information it acquires thanks to the relationships it has whereas “structural embeddedness” is mainly arising from the position covered from the focal subsidiary within the network (Andersson *et al.*, 2002: 980-982). A specific form of relational embeddedness is the so called “business embeddedness” where “actors have known each other for a long time, have transacted over a long period, have adapted their business conduct to each other and are used to exchanging information about market conditions” (*ibidem*). Corporate or internal embeddedness mirrors the company-internal country-specific relationships, which are within the international company international by nature. External or business-market embeddedness is per definition the external environment in which the multinational company is located. A further specification is “technical embeddedness” that results from product and production development process exchanges among firms located in the competitive environment. Improvement and adaptation mechanisms constitute a considerable part of those interdependencies. The authors test the influence of subsidiary business and technical embeddedness on the importance of those subsidiaries for competence development within the multinational company and on their market performance analyzing a sample of Swedish multinational companies. They realize that a subsidiary being technically embedded is obtaining a positive market performance from its exchanges with external firms. Moreover, also the role of the subsidiary as a knowledge provider and competence developer within the multinational company is sustained by its interdependencies with the external environment. Finally, business embeddedness has been provided to be beneficial both for subsidiary market performance and competence development. A trade-off is to be recognized between the external knowledge development and the internal deployment of those competencies. Therefore, the subsidiary corporate embeddedness should be sustained by the headquarter in order for the whole multinational company to profit from the subsidiary external network.

Doz and Prahalad (1984) have already debated the trade-off between national re-

sponsiveness on the headquarter side and global integration on the subsidiaries side. The internal integration strategy put forward by the headquarter in order to subsume the external national political and economic framework with the internal organizational structure of the multinational company is usually complemented and challenged from the diversity in the markets subsidiaries are acting in and the need to overcome this one and strategically respond to those global externalities and market conditions. The authors identify three management tools that can manage strategic decisions within the multinational company and control those processes. These tools are data management for making the right decisions, managers' management for reaching consensus and arriving to a final decision and finally conflict resolution for creating the right power balance among decisions makers within the multinational company.

Agency theory within the multinational company relates to all those implemented mechanisms in order to overcome internal fights of interests and reach an outcome, which should be efficient for the multinational company as a whole. Monitoring e.g. through the sending of expatriates abroad, incentives e.g. for transferring knowledge to other units of the multinational company as well as socialization mechanisms have been introduced in this section and briefly debated thanks to some relevant contributions of the international business and international management literature. References to the external environment in which the multinational company acts has been presented within the concept of embeddedness. The third chapter of the present work aims at going into details in the game-theory literature in order to shed light on game-theoretical models, which have been developed in order to analyze the organizational structure, the information distribution, the authority and the relationships between agents within organizations. The structure adopted is the same that has been presented within the second chapter.

2.5 Implications for the model

Focus of the previous sections was the screening of the international business and management literature concerning the organizational structure of the multinational company

and the knowledge flows arising within this structure as well as with the external environment of the multinational company. Moreover, some company-internal mechanisms have been introduced in terms of authority and power as well as considering the divergent interests that are pursued within the multinational company. The theoretical model, which will be presented within chapter 4 of the present work, is able to cover the peculiarities of the multinational company as follows. First of all, the model mirrors the structure of the multinational company in having one headquarter in the home country and some subsidiaries abroad. Moreover, the peculiarities of the so called "centre of excellence"²⁴ will be introduced in the model and will play a crucial role in the answering of the research question.

Information flows are described within the model as internal knowledge spillovers within the company structure as well as external knowledge spillovers arising from the exchanging relationships with competitors in the markets where subsidiaries are operating. The knowledge flows arising from both company-internal and external spillovers will differ in accordance to the role played by the headquarter and the subsidiaries in the knowledge production and diffusion process. Accordingly, the model is able to capture the knowledge intensity derived from the participation to those processes.

The concept of power can be found in the model within the hierarchical structure of the company as well as thanks to the different nature of the knowledge stocks produced by the involved actors. In fact, in accordance to the management and international business literature the headquarter is assumed to produce general knowledge of relevance for the company as a whole whereas subsidiaries are assumed to produce context-specific knowledge due to their being part of a specific regional market and thanks to their interactions with their local competitors. Hence, embeddedness is involved in the model as well.

²⁴See *supra*.

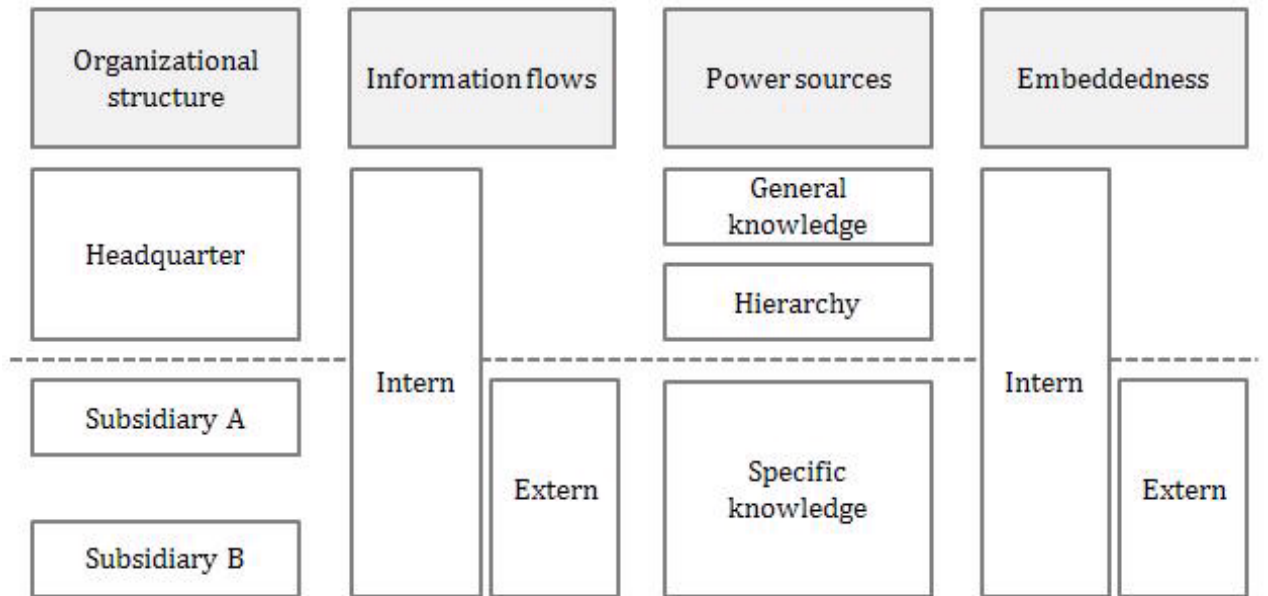


Figure 2.6: Implications for the model from the management and international business literature (own representation)

Chapter 3

Knowledge transfer and organizational structure: a review of the economic literature

Knowledge transfer procedures have been of concern in the economic literature as well. In fact, knowledge owning, production and transfer have an influence in the structure of hierarchies, which can be found in companies e.g. in terms of span of control. This aspect will be treated in the next subsection 3.1. Moreover, information asymmetries mirror the core of the well-known principal-agency theory, according to which the better informed party can influence the decision process and implement his/her personal interests damaging the less informed contract party. These aspects together with the definition and role of specific knowledge is introduced in subsection 3.2 as well. The concept of authority is connected to knowledge ownership as well. This will be debated in subsection 3.3. Finally, research joint ventures as a quite recent organizational means of sharing research effort as well as research findings among non-competing and competing firms will be presented in the final section 3.4 of the present chapter in order to clarify the theoretical foundations lying at the basis of the next chapter 4.

3.1 The structure of hierarchies

The investigation of organization structures and mechanisms is not new to the game-theoretical literature. The design of hierarchies combined with the roles of “coordinator” and “specialist” has been model by Hart and Moore (2005). The authors create a framework in which two agents specialize on one asset each and are coordinated by a third person who

is in charge of the project implementation thanks to the combination of the two assets. They investigate the organizational form in terms of seniority and decision making power. Their contribution to the literature bases on the fact that hierarchy is not defined in terms of information available, but in terms of authority. The coordinator should therefore be senior to the two specialists and has lower probability of having ideas for projects due to the dimension of his/her span of control. Should the coordinator have a project idea, then he/she will immediately implement it. Should not he/she have one, then each specialist can implement their projects, if they have one. Hence, knowledge coordination requires a senior position to be efficiently executed.

The quest for the optimal structure of hierarchies relies directly to the search for the best organizational structure. The quest for the most efficient organizational structure has been debated by Aghion and Tirole (1995), who analyze whether a unitary organizational form (U-form) or a multidivisional organizational form (M-form) guarantees the best allocation of tasks. Some considerations on core and periphery units with overload aspects are also to be found. In the previous chapter, the several evolution stages the multinational company was involved with have been presented¹. Those stages mirrored the several modifications for the reaching of the optimal organizational structure. One aspect of relevance has been identified in the coexistence of local elements, supported by the subsidiaries, with the central standardization set up by the headquarter. The trade-off between standardization and local adaptation at the corporate level, which has been extensively treated in the previous chapter of the present work, has been approached in the economic literature as well and has been modeled by Dessein *et al.* (2009), who identify an incentive conflict between the corporate managers and the business unit managers due to their pursued organizational structure, especially after a merger. Synergies from integration can be reached standardizing some activities, e. g. manufacturing, at the corporate level while leaving some other activities, e. g. marketing, at the business unit level. Therefore, the incentive system should be put in place such that corporate managers are motivated to

¹See *supra*, section 2.1.1.

establish standardized activities of high value, and business unit managers are willing to communicate credibly or to bargain with the corporate managers.

To sum up, the study of hierarchies and knowledge transfer within the economic literature refers mainly to the authority position covered within the hierarchy, to the quest for the most efficient organizational structure as well as to the adoption of the right incentives systems.

3.2 Information asymmetries and specific knowledge

Asymmetric information is a crucial aspect covered by the game-theoretical literature. The informed actor has in fact the possibility to influence the negotiation of the contract in order to reach the own interests, which are not a priori known from the uninformed actor involved in the contract. This section is devoted to the analysis of the acquisition of information within a principal-agent relationship as well as with the consequences the access to those information has in the relationship itself.

A model on information transparency within B2B exchanges in electronic markets is provided by Zhu (2004). The firms participation on a platform for information exchanges about cost delivers profits to low-cost firms both under quantity and price competition. The participation of high-cost firms in the B2B exchange is profitable only under price competition and under the assumption that the goods traded are complements. A similar framework should be recognized every time in which the headquarter is negotiating a contract for a project and decides to involve or not the subsidiary in the project execution. The possible involvement of the subsidiary is connected to the access to additional information for the headquarter in a similar way as the participation in the B2B exchange for the member firms.

As already discussed within the previous chapter, the owning of information can be considered as a power source. Dessein (2002) elaborates a model in order to discuss and investigate why an uninformed principal spontaneously gives decision rights to an agent, who has more and better information at disposal, but who pursues divergent objectives.

The author starts from a principal-agent model where the principal screens the projects, can contract authority and has the control over the resources needed for the projects implementation and the agent has access to superior information. The key findings of the author rely on the trade-off between delegating decisions rights and communicating with the agent holding the relevant information. On the one hand, communication implies a significant loss of information since the agent involved will screen the information according to the own interests before transferring it. On the other hand, delegation of decision rights implies a loss of control on the overall process, but it has been proved to represent a more efficient policy for using the information the agent has. A further finding that is relevant for organizational design is that authority should be centralized only when the information needed for decision making are centrally available or can be verified within the lower levels of the hierarchy.

The previous chapter of the present work has introduced the concept of specific knowledge as the knowledge that is difficult to be transferred and arises from learning, as defined by Jensen and Meckling (1992). The superior knowledge an agent has may be of several natures and may be based on several sources of information e.g. about the profitability of projects to be implemented, production processes, pricing strategies, market conditions, technology and investment decisions. Raith (2005) tries to capture the features a contract should have when an agent has specific knowledge of how the input translate into output. Incentives should be given to the agent according to the value its specific knowledge has for the principal. The author realizes that output-based performance measures should be implemented in such a framework, such that the agent has an incentive to use actively its specific knowledge in order to reach the best output.

3.3 Formal vs. real authority

The separation of ownership and control within organizations has extensively been treated within the game-theoretical literature. The first authors providing a contribution are Fama and Jensen (1983). Aghion and Tirole (1997) investigate formal and real authority

in organizations. They define formal authority as the “right to decide” and real authority as “the effective control over decisions”. According to the authors, the information allocation and distribution determines real authority, but it is itself determined by formal authority. “By giving the subordinate formal authority over both initiation and ratification, the boss may greatly improve the subordinate’s incentive to search for and developed projects, and these benefits can outweigh the costs of the poor projects that are sometimes implemented”. An additional model on informal authority in organizations has been developed by Baker *et al.* (1999) and bases on the findings of Aghion and Tirole (1997), which have been presented in the lines above. The authors try to detect whether authority centralization or authority delegation is the optimal decision making structure. Two fundamental assumptions of the authors are the following: the principal (“boss”) allows bad decisions to be reached by the agents (“subordinates”) and the agents tend generally speaking to abuse the authority they have. After having introduced the efficiency of informed centralization and contractible delegation, two models of informal authority have been elaborated by the authors. In the framework of the first model the boss is “informed”, that is to say, the boss observes the project results before ratifying it. Within this context there are environments where informal delegation, that is the situation in which the principal allows an agent to act, is efficient and feasible (Baker *et al.*, 1998: 10). As in the paper of Aghion and Tirole (1997), “under informal delegation, the boss may feel regret over a decision that she allows the subordinate to make, ratifying a project that she knows is bad in spite of her ability to overrule. The boss does this because, by accepting all the subordinate’s recommendations, she may greatly improve the subordinate’s incentive to search for and develop projects, and these benefits can outweigh the costs of the poor projects that are sometimes implemented” (Baker *et al.*, 1998: 10). Informal delegation is not feasible within the model with an informed boss when the interests of both parties are highly correlated and the boss has the temptation not to ratify a project even though he/she has promised to do so. In this scenario the boss will destroy his/her reputation as a delegator.

A contrasting picture is provided by the model elaborated by the authors with an

uninformed boss. In this situation the boss is not able to judge the benefits connected to the project implementation. Examples of this situation are “large investments where the boss relies heavily on subordinate expertise when ratifying projects; small decisions [...] that do not warrant monitoring prior to implementation; and decisions over investment opportunities that arise quickly and would disappear before the boss could conduct a careful analysis” (Baker *et al.* 1999: 12). In order to avoid vetoing or approving all the projects proposed by the subordinates, the boss can give to them a so called informal authority according to which the subordinate is paid an “efficiency wage” for not abusing this authority and for proposing to the boss only projects that guarantee high benefits. Once again reputation plays an important role but on a reversed perspective compared to the model with an informed boss. In fact, the novelty introduced by the authors relies on the focus on subordinates’ actions, which should comply with their role as responsible authority users receiving their efficiency wage and implementing only those projects connected with an high outcome for the boss.

The traditional game-theoretical literature focusing on principal-agent relationships assumes that the principal is supposed to control the agent in order for this one to act in compliance with the principal’s interests. Reward and punishment mechanisms should be developed accordingly. Jost (2002) provides a contribution to this literature stream comparing a so called ‘commitment model’ with a ‘non-commitment model’. In the commitment model, the principal exhibits his/her commitment to monitor the agent, that is to say, the monitoring intention declared when finalizing the contract will be exactly the same at contract conclusion. The monitoring in this model responds to two main needs of the principal: first of all, detecting cheating at low outcome levels in order to prevent the agent to become lazy. Secondly, rewarding the agent working hard at higher outcome level. Monitoring will therefore diminish at higher outcome levels (decreasing function in the level of outcome), since it seems quite straightforward that the agent is working hard at high outcome levels. On the contrary, within the non-commitment model elaborated by the author “the monitoring policy announced by the principal at the time of contracting

is not binding at the time of performance” (Jost, 2002: 7). The principal is not credible to the agent since monitoring is costly and the principal will always try to avoid these costs. The purpose of monitoring changes drastically within this scenario since the principal is no more interested in detecting cheating at low outcome level. For the same reason, the principal is also not willing to monitor at higher outcome levels due to the connected costs. Therefore, monitoring will take place only at higher level of outcome and will imply a lower award for working hard, which will cover the marginal costs of the monitoring by the principal. Within the non-commitment model, the monitoring probability increases at higher level of outcome. In some sense, the incentive mechanisms of the commitment model at high outcome levels (reward for working hard) become punishment mechanisms within the non-commitment model (reduction in payment to the agent due to monitoring costs incurred by the principal). After having introduced some perspectives of analysis from the game-theoretical literature in order to answer the central research question, another view from the economic literature will be presented in the following section 3.4 with focus on research joint ventures. In fact, the relationship between headquarter and abroad subsidiaries of the multinational company is not only an example of a principal-agent relationship. In fact, this relationship can also be elucidated from an economic point of view in terms of the benefits of investing in knowledge together.

3.4 The emerging of Research Joint Ventures

Research joint ventures (RJVs) arise in the last 40 years thanks to a general economic deregulation and changes in competition law. Two categories of cooperations in R&D can be identified in the theoretical literature (Kamien *et al.*, 1992: 1294-1295): on the one hand, R&D cartelization and RJV cartelization, in which firms coordinate their R&D effort in order to autonomously (R&D cartel) or collectively (RJV cartel) maximize their profits, and on the other hand, R&D or RJV competition, in which firms unilaterally decide on their R&D investments and then decide autonomously (R&D competition) or cooperatively (RJV competition) how to act on the market.

Model	First stage (R&D)	Second stage (production)
R&D competition (case N)	Firms compete; each firm decides its own R&D level given R&D investments of other firms	Firms compete; marginal cost of production is decreased by the firm's own R&D effects, in addition to some spillover from other firms' R&D
R&D cartelization (case C)	Firms coordinate their R&D activities so as to maximize sum of overall profits	Firms compete; marginal cost of production is decreased by the firm's own R&D efforts, in addition to some spillover from other firms' R&D; the spillover is not increased because of the cartelization
RJV competition (case NJ)	Firms compete; each firm decides its own R&D level given R&D investments of other firms; firms share R&D efforts and avoid duplication of R&D activities	Firms compete; marginal cost of production is decreased by the sum of all R&D efforts in the industry (spillover increased to its maximum level)
RJV cartelization (case CJ)	Firms coordinate their R&D activities so as to maximize the sum of the overall profits; firms also share R&D efforts and avoid duplication of R&D activities	Firms compete; marginal cost of production is decreased by the sum of all R&D efforts in the industry (spillover increased to its maximum level)

Figure 3-1: The four scenarios in research joint ventures (from Kamien *et al.*, 1992: 1295)

The most crucial incentives firms enjoy when doing research together with other firms are the following (Röller *et al.*, 1997; Veugelers, 1998): first of all, firms can internalize R&D spillovers and overcome free-rider attitudes. This increase the expenditures firms are willing to incur for doing R&D once the free-rider problem has been limited. Secondly, research joint ventures are associated with cost savings since R&D costs may be shared among the companies involved in the joint venture. Therefore, duplication costs can be avoided and existing resources can be pooled. Moreover, firms involved have access to partners' know-how, to their products and their markets. Thirdly, asset complementarities may provide a strong incentives for participating in RJVs. Fourthly, firms can share risks through RJVs and sometimes profit of the financial stability of other firms involved, overcoming financial constraints. Fifthly, firms selling complementary products have proved to have stronger incentives in joining RJVs than firms producing substitute products. Sixthly, large firms are usually more willing to participate in RJVs with large firms than with smaller ones. Finally, government policy can also represent an incentive for joining RJVs since e. g. subsidies for cooperation may be granted.

However, some problems of allying should be mentioned as well (Veugelers, 1998): first, start-up investments may become prohibitive, e. g. in term of negotiation costs or through the establishment of a very specific infrastructure. Secondly, agency and coordination problems may arise throughout the venture agreement. Thirdly, the concrete quality of a firm's output is a priori unknown, such that information asymmetries play a crucial role in the a priori evaluation of the partner to be selected. Finally, information flows among the firms involved should be controlled as well.

Research joint ventures affect firms participating to those venture differently as those firms, which are not involved. Therefore, thanks to their exclusivity component RJVs are usually defined as an instrument to obtain and retain market power, since they are able to provide modifications in the external market structure as well, e. g. in the form of market asymmetries.

When joining RJVs the characteristics of the partner(s) play a substantial role.

Similarity, size and absorptive capacity² are the most crucial aspects to be considered (Veugelers, 1998). These dimensions are quite crucial for the purpose of the present work as well, such that it is worth mentioning the literature efforts done in explaining the dynamics underlying them. The reasoning the headquarter of a multinational company is involved with when allocating the R&D processes in house or abroad are much similar to the reasoning companies have when approaching the decision of engaging in a research joint venture.

After having shedded light in the directions of research concerning knowledge transfer and organizational structure within the economic literature, the concrete implications for the theoretical model presented in chapter 4 are derived in the next subsection 3.5.

3.5 Implications for the model

As already described within some lines above, the game-theoretical and economic literature suggests many theoretical approaches that can be applied to investigate the strategic knowledge interactions and information flows within the organizational structure of the multinational company responding to the central research question of the present work. Starting from the same dimensions presented in the previous chapter 2, the current section summarizes these approaches and focuses on those, which will underly the theoretical model in chapter 4.

The organizational structure of the multinational company has been extensively debated with the previous chapter 2. For the purpose of the research question, the multinational company object of analysis is supposed to have an headquarter in the home country and two subsidiaries in two different markets or countries abroad. Accordingly, the headquarter

²The definition of absorptive capacity is not new to the industrial organization literature and bases on the assumption that past experience influences the elaboration of new insights and helps firms in making best use of them. Cohen and Levinthal (1990: 128) state that "prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends". Starting from this definition, Kamien *et al.* (1992) conclude that the benefit a firm can derive from others' R&D is a measure of the own R&D efforts. Leahy and Neary (2007) analyse the theoretical implications of a firm's absorptive capacity and prove that engaging in own R&D enhance the spillovers arising from external R&D.

will act as a principal and the two subsidiaries as agents. Moreover, the headquarter will have a coordination role with respect to the specialist function of the two subsidiaries due to their local presence in their respective markets, to which the headquarter has not direct access.

The interests of headquarter and subsidiaries are in some sense divergent. In fact, the headquarter aims at providing process standardization over the whole company whereas subsidiaries focus mainly on adapting to their local circumstances. This peculiarity has been defined in the management and international business literature as the trade-off between general (HQ) knowledge and specific (subsidiaries) knowledge. As a consequence, the headquarter is given the option to delegate some or all knowledge production processes to one or both subsidiaries thanks to their high specialization, local adaptation and regional market knowledge in order to maximize the company profits.

The model assumes that internal knowledge flows will take place within the multinational company. On the contrary, external knowledge flows will take place in the regional markets involved thanks to the knowledge exchanges both subsidiaries have with external competitors, suppliers and customers. As a result, the model will be able to capture the concept of embeddedness, both company-internal and external.

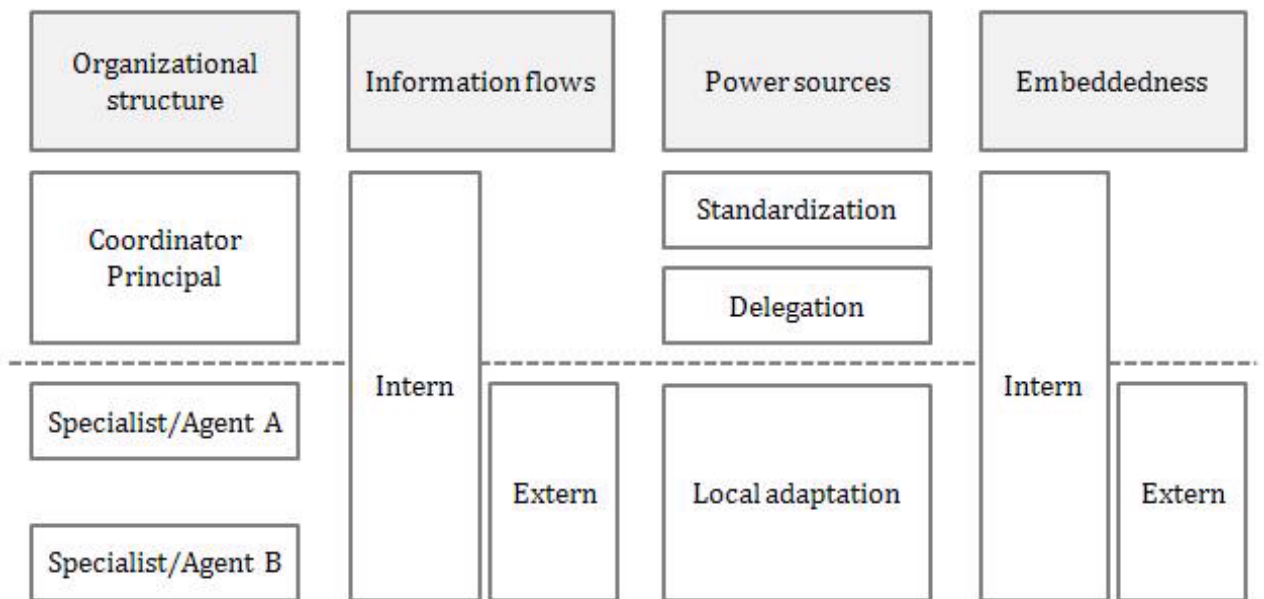


Figure 3.2: Implications for the model from the game-theoretical and economic literature (own representation)

Chapter 4

The model

“To know that we know what we know, and to know that we do not know what we do not know, that is true knowledge”

[Nicolaus Copernicus]

After having introduced the international business and management literature on multinational companies in chapter 2 and after having presented some possible economic perspectives of analysis within chapter 3 of the present work, a theoretical model will be elaborated within this chapter.

The following theoretical model aims at investigating the research question presented at the beginning of the present work within chapter 1 whether the headquarter of a multinational company with subsidiaries abroad should involve (all or some of) these subsidiaries in the knowledge development processes or whether those knowledge development processes (i. e. R&D) are more profitable to be carried out centrally. The model describes a multinational company composed of three main actors: a central headquarter and two abroad subsidiaries located in two different markets. Object of investigation within the model is not only the organizational structure of the multinational company, but also the features of the knowledge produced and transferred within this organizational structure. In fact, "knowledge with different characteristics needs different organizational mechanisms to facilitate the transfer of that knowledge" (Foss and Pedersen, 2002: 64)¹.

Three scenarios will be analyzed within the model. First of all, the *decentralized knowl-*

¹See *supra*, section 2.2.4 of the present work.

edge investment policy (scenario 1) is introduced, according to which the two subsidiaries abroad are actively and exclusively involved in the knowledge production and diffusion processes. As a consequence, the headquarter is not playing an active role within those processes. The knowledge produced by the two subsidiaries is supposed to be locally embedded and context-specific thanks to the experience each subsidiary has matured in its own external environment. This is consistent with the international management literature, where these external interactions have been defined as "learning" (Mudambi and Navarra, 2004: 389)². Furthermore, this kind of knowledge is also defined as "network-based knowledge" (Foss and Pedersen, 2002: 55-56) since its origin derives in the long-lasting relationships with external parties³. Hence, this knowledge is hardly transferable to other units of the multinational company, since absorptive capacity is embedded in the process itself (Björkman *et al.*, 2004: 444)⁴.

Secondly, the *centralized knowledge investment policy* (scenario 2) is analyzed as a counterpart of scenario 1, in which knowledge investments are only conducted centrally from the headquarter without any participation from the two local subsidiaries. The knowledge produced by the headquarter has the features of general and internal knowledge, since it originates from internal routines and is usually easy to be transferred within the multinational company (Foss and Pedersen, 2002: 55-56)⁵. Moreover, this kind of knowledge is usually not of high relevance for the external environment. However, it will be assumed that local subsidiaries do not accept this top-down knowledge, since they have not been involved in the knowledge development process.

Thirdly, scenario 3 combines the perspectives of analysis of the precedent scenarios presenting *headquarter intervention within decentralized knowledge investment policy*, where the headquarter has the option to delegate a portion of knowledge production to a highly-specialized subsidiary defined as a centre of excellence (Forsgren *et al.*, 2000: 45)⁶. There-

² See *supra*, section 2.2.2 of the present work.

³ See *supra*, section 2.3.2 of the present work.

⁴ See *supra*, section 2.2.2 of the present work.

⁵ See *supra*, section 2.2.4 of the present work.

⁶ See *supra*, section 2.2.1 of the present work.

	Decentralization (scenario 1)	Centralization (scenario 2)	HQ intervention within decentralization (scenario 3)
Actively involved actors	Subsidiary A and B	HQ	HQ and subsidiary A acting as centre of excellence
Testing the competitive advantage of the MNC (Foss and Pedersen, 2002: 54)	No competitors in market A and B		
Knowledge transferred	Locally embedded and context-specific <ul style="list-style-type: none"> ▪ "learning" (Mudambi and Navarra, 2004: 389) ▪ "network-based knowledge" (Foss and Pedersen, 2002: 55-56) ▪ Absorptive capacity in the process itself (Björkman <i>et al.</i>, 2004: 444) 	General <ul style="list-style-type: none"> ▪ "internal knowledge" (Foss and Pedersen, 2002: 55-56) 	Highly specialized <ul style="list-style-type: none"> ▪ "centre of excellence" (Forsgren <i>et al.</i>, 2000: 45)
Implications from the knowledge transferred	Hardly transferable to other units <ul style="list-style-type: none"> ▪ "motivational problem" (Foss and Pedersen, 2002: 53) 	Local subsidiaries do not accept centrally produced knowledge. Knowledge is of no relevance for the external environment.	Very high external spillovers due to the recognition of the CoE in the external environment, but immediate knowledge use within the MNC

Figure 4.1: Structure of the model (own representation)

fore, both the headquarter as well as the centre of excellence may participate to knowledge production and transfer. The stock of knowledge produced by the centre of excellence is highly specialized. Moreover, the activity of the centre of excellence is well-known in the external market, such that very high external knowledge spillovers are to be recognized. The good reputation of the centre of excellence applies also within the multinational company, such that the knowledge produced is of immediate company-internal use.

The three scenarios are then compared in terms of knowledge intensity and realized profits.

4.1 General assumptions of the model

As already elucidated within some lines above, the model of the present work focuses on a multinational company, which is composed for simplicity of three main actors: the headquarter, subsidiary A and subsidiary B. The headquarter is located in the home country and controls two subsidiaries A and B located in two different countries/markets respectively A and B. The crucial decision the headquarter has to face is where to allocate its knowledge (R&D) production. The headquarter has basically following possibilities at disposal:

1. the subsidiaries may be exclusively involved in the knowledge investment processes without any participation from the HQ. This case is referred to as *decentralized knowledge investment policy* and will be looked at within "scenario 1" in section 4.2.
2. The HQ may be exclusively involved in the knowledge production processes without any involvement from the two subsidiaries A and B. This second case is referred to as *centralized knowledge investment policy* and will be presented within "scenario 2" in section 4.3.
3. A combination of the two precedent scenarios where the headquarter is given the option to delegate a portion of the knowledge investment of the company as a whole to a specific subsidiary defined as a centre of excellence. This third possibility is defined as *headquarter intervention within decentralized knowledge investment policy* and will be analyzed within "scenario 3" in section 4.4.

For the purpose of the model it will be assumed that all the firms respectively in market A and B are identical.

4.2 Scenario 1: decentralized knowledge investment policy

Subsidiary A and B are the main actors within the decentralized knowledge investment scenario. Acting respectively in two different markets/countries A and B, they are able

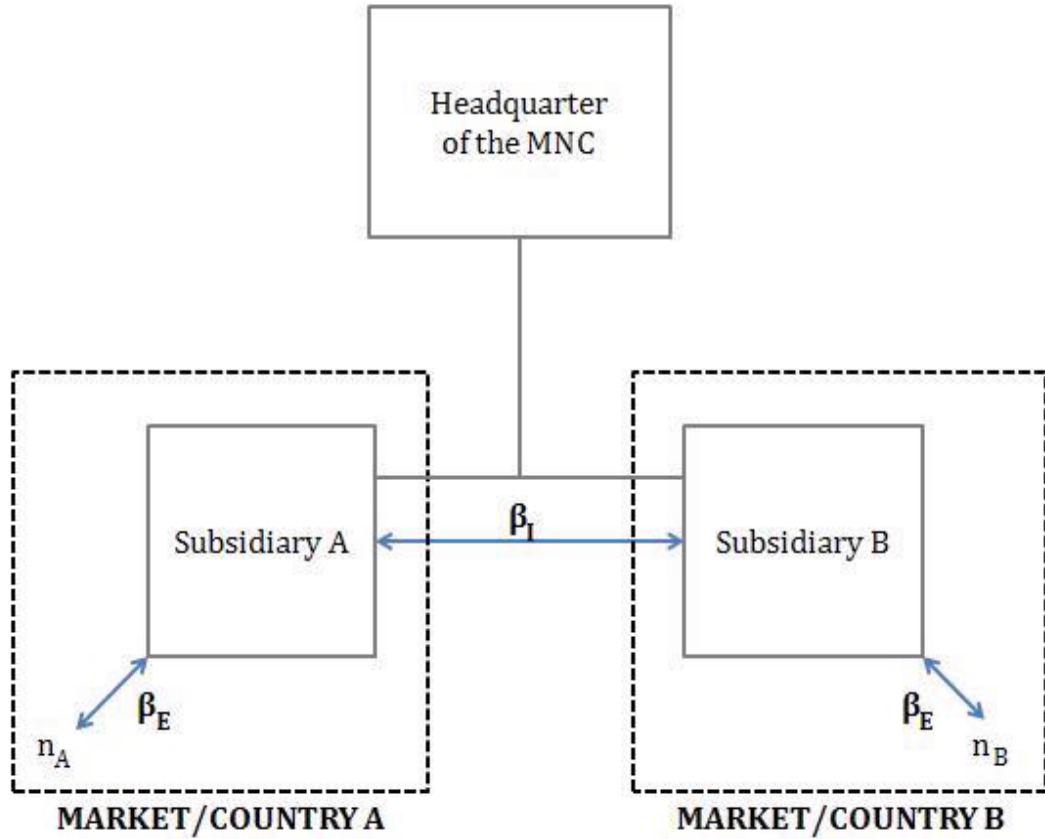


Figure 4.2: Structure of the MNC and knowledge spillovers under decentralized knowledge production (own representation)

to establish a network of exchanges with their own external environment composed respectively of n_A and n_B competitors in market A and B. The international management literature refers to those information exchanges as "relational embeddedness" (Andersson *et al.*, 2002). Two kind of knowledge flows take place within this scenario: internal spillovers β_I between subsidiary A and B due to their belonging to the multinational company as well as external spillovers β_E among all the firms in the respective markets/countries A or B and between those firms and the focal subsidiary A or B.

4.2.1 Effective knowledge investments under decentralized knowledge investment policy

The effective knowledge investments of subsidiary A under decentralization depend not only on its own individual investment x_A but also on the investments of subsidiary B x_B in the other market (thanks to being part of the same multinational company) as well as on the knowledge investments of all the other companies in market A defined as $\sum_{a=1}^{n_A} x_a$.

Therefore, effective knowledge investments of subsidiary A⁷ are displayed within equation (4.1) that follows,

$$X_A^d = x_A + \varphi\beta_I x_B + \beta_E \sum_{a=1}^{n_A} x_a \quad (4.1)$$

where φ captures the complementarity between products (or production processes) in market A and B and it is assumed that $\varphi \in [0, 1]$.

This implies that subsidiary A and B can profit reciprocally from the knowledge investments in the other market for positive values of $\varphi\beta_I$. β_I represents the company's internal spillovers parameter with $\beta_I \in [0, 1]$. Moreover, also external spillovers common not to the company object of analysis but common to the industry are to be recognized. These are defined with β_E . Some typical examples of spillovers are the grant of patents, informations in scientific publications, employees migration across firms (e.g. the sending of expatriates⁸ in the multinational company case), from suppliers as well as from customers. For $\varphi = 1$, the specific knowledge produced by one subsidiary becomes of relevance for the whole MNC (general knowledge) and can be immediately absorbed from the headquarter. In the opposite case, where $\varphi = 0$, no knowledge flows can take place among the subsidiaries or the headquarter, such that the result of knowledge investments remains a private good due to the high specificity of the knowledge produced. Smaller values of $\varphi\beta_I$ refers to the adaptation costs the headquarter or the other subsidiary should incur in order to adapt

⁷For the calculations related to market B (subsidiary B and its competitors) please refer to Appendix 1 at the end of the present work.

⁸See *supra*, section 2.4.1 of the present work.

the investments to their knowledge requirements and features.

The factor $\sum_{a=1}^{n_A} x_a$ mirrors the knowledge investments of all the other companies acting in the market A. It is assumed that those competitors invest in isolation in knowledge, such that no company's internal spillovers may be gained from their investments in knowledge. Due to their isolated knowledge investments they display a different knowledge investment function compared to the single subsidiary involved in one of the two markets as displayed in the following equation (4.2).

$$X_i^d = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a + \beta_E x_A = (1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A \quad (4.2)$$

The effective knowledge investments of all competitors in market A depend first of all on their own individual knowledge investment x_i , then on the investments of all the other companies acting in the same market $\beta_E \sum_{a=1, a \neq i}^{n_A} x_a$ as well as on the investment of subsidiary A through the existence of external knowledge spillovers in market A defined as $\beta_E x_A$.

4.2.2 Cost functions under decentralized knowledge investment policy

The cost functions of both subsidiary A as well as all competitors in market A display that knowledge investments aim at reducing production costs. This is consistent with the main assumptions in the economic literature and implies that high knowledge intensity has positive implications in the cost structure of the company involved.

$$C_A^d(q_A, X_A^d) = (c_A - X_A^d) q_A = \left(c_A - \left(x_A + \varphi \beta_I x_B + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_A \quad (4.3)$$

Subsidiary A profits from the knowledge investments of subsidiary B $\varphi \beta_I x_B$ for positive values of $\varphi \beta_I$. Positive values of β_E allows for learning from the external environment.

$$C_i^d(q_i, X_i^d) = (c_i - X_i^d) q_i = \left(c_i - \left((1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A \right) \right) q_i \quad (4.4)$$

The same reasoning applies to the competitors in market A, which are allowed to profit from the knowledge policies of the other firms in the same market as well as from subsidiary A for positive value of β_E .

The cost functions underline the crucial role played by both internal and external knowledge spillovers within the multinational company (between subsidiary A and B) as well as with the respective market of reference (among all the firms in the market).

4.2.3 Profit maximization functions and optimal output under decentralized knowledge investment policy

Once the cost functions have been introduced within the model, the profit maximization functions can be looked at. The profit maximization function of subsidiary A reads as follows:

$$\max_{q_A} \pi_A^d = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_A - X_A^d) \right) q_A - \frac{x_A^2}{2} \quad (4.5)$$

Both the output of all competitors in market A defined as $\sum_{a=1}^{n_A} q_a$ as well as the output of subsidiary A q_A are crucial for profit calculation. Moreover, the effective knowledge investments of subsidiary A X_A^d have a positive impact on the profits of the multinational company since they aim at reducing costs as already explained some lines above.

The cost of investing in knowledge production $\frac{x_A^2}{2}$ are assumed to be quadratic due to diminishing returns to R&D expenditures (cf. D'Aspremont and Jaquemin, 1988)⁹.

For another firm $i = 1, \dots, n_A$ in the market A or firm $j = 1, \dots, n_B$ in the market B

⁹For the purpose of the model and for simplicity it has been assumed that $c_A = c_i$ or that $c_B = c_j$. This implies that unitary costs are the same over the whole industry (for both subsidiaries and competitors in the market). Different cost structures arise from divergent knowledge investment policies, which aim at reducing costs.

maximize their profits according to the following function:

$$\max_{q_i} \pi_i^d = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^d) \right) q_i - \frac{x_i^2}{2} \quad (4.6)$$

Accordingly, the optimal quantities of subsidiary A and of all the other competitors in market A can be derived¹⁰. As already specified above, all other firms in market A are identical, such that $q_i^* = q_a^*$ and $C_i^d = C_a^d$.

Solving the FOC for $\frac{\partial \pi_i^d}{\partial q_i} = 0$ the optimal output q_a^* can be calculated and reads as:

$$q_a^{d*} = \frac{1}{b_A (n_A + 2)} \left(a_A - 2C_a^d + C_A^d \right) \quad (4.7)$$

The same applies to q_A^* for $\frac{\partial \pi_A^d}{\partial q_A} = 0$, which reads as:

$$q_A^{d*} = \frac{1}{b_A (n_A + 2)} \left(a_A - (n_A + 1) C_A^d + n_A C_a^d \right) \quad (4.8)$$

The following profits result respectively for the competitors in market A as well as for subsidiary A

$$\Pi_a^{d*} = \frac{(a_A + C_A^d - 2C_a^d)^2}{b_A (n_A + 2)^2} - \frac{x_a^2}{2} \quad (4.9)$$

$$\Pi_A^{d*} = \frac{(a_A + n_A C_a^d - (n_A + 1) C_A^d)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} \quad (4.10)$$

4.2.4 Optimal knowledge investments under decentralized knowledge investment policy

As soon as the profit functions are known, the optimal knowledge investment quantities may be derived¹¹ as follows for all the actors involved in the model (respectively for the

¹⁰For the proof of these equations please refer to Appendix 1 at the end of the present work.

¹¹For the proof of these equations please refer to Appendix 1 at the end of the present work.

competitors in market A, for subsidiary A, for the competitors in market B and for subsidiary B):

$$\begin{aligned}
x_a^{d*} &= z_A (-w_B (g_B + d_B t_B z_B) (r_A s_A w_A + \varphi \beta_I)) + \dots & (4.11) \\
&+ z_A r_A (1 + r_B t_B w_B z_B) (d_A - g_A w_A) + \dots \\
&+ z_A w_B (\varphi \beta_I - s_A w_A) (s_B - t_B z_B \varphi \beta_I)
\end{aligned}$$

$$x_A^{d*} = w_A ((1 + r_B t_B w_B z_B) (g_A + d_A t_A z_A) + w_B (s_A - t_A z_A \varphi \beta_I) (d_B t_B z_B + g_B)) \quad (4.12)$$

$$\begin{aligned}
x_b^{d*} &= z_B (-w_A (g_A + d_A t_A z_A) (r_B s_B w_B + \varphi \beta_I)) + \dots & (4.13) \\
&+ z_B r_B (1 + r_A t_A w_A z_A) (d_B - g_B w_B) + \dots \\
&+ z_B w_A (\varphi \beta_I - s_B w_B) (s_A - t_A z_A \varphi \beta_I)
\end{aligned}$$

$$x_B^{d*} = w_B ((1 + r_A t_A w_A z_A) (g_B + d_B t_B z_B) + w_A (s_B - t_B z_B \varphi \beta_I) (d_A t_A z_A + g_A)) \quad (4.14)$$

4.2.5 Testing the definition of the multinational company under decentralized knowledge investment policy

Once the setup of the model has been identified, the organizational structure of the multinational company as well as the nature of the developed knowledge stocks can be further investigated.

First of all, the definition of the multinational company has been presented at the beginning of the present work within chapter 2. This definition relies first of all in the organizational structure of the multinational company thanks to the abroad market presence. This has been modeled with subsidiary A and B. Furthermore, it has been identified

that the most valuable strenght of the multinational company is that of the transferring of knowledge within the company from the unit generating it to those units able to generate value-added with that knowledge¹².

In order to test this assumption and to stress the focus on the company-internal knowledge flows β_I , it will be assumed in the following that the multinational company has no competitors in the two markets A and B, such that $n_A = n_B = 0$.

Conclusion 1 *If the subsidiaries of the MNC do not have any competitors in their respective markets, then the higher the company internal spillovers, the higher the profits of the MNC.*

For $n_A = 0$ the profits of subsidiary A reads as:

$$\Pi_A^d = \frac{((a_A - c_A)(2 + \varphi\beta_I^2) + (a_B - c_B)2\varphi\beta_I)^2 - 2b_A((a_A - c_A) + (a_B - c_B)\varphi\beta_I)^2}{4b_A} \quad (4.15)$$

Proof. For $\varphi \in [0, 1]$ and $\varphi \neq 0$, then $\frac{\partial \Pi_A^d}{\partial \beta_I} = \frac{(4\varphi\beta_I(a_A - c_A) + 4\varphi(1 - b_A)(a_B - c_B))^2}{4b_A} > 0$. ■

Due to the fact that $\frac{\partial \Pi_A^d}{\partial \beta_I} > 0$, it can be herewith confirmed that the internal knowledge spillovers are the crucial success factor of the multinational company. The higher the internal knowledge flows within the multinational company, the higher the profits of the focal subsidiary A.

Conclusion 2 *If the subsidiaries of the MNC do not have any competitors in their respective markets, then the higher the company internal spillovers, the higher the optimal knowledge investment of the focal subsidiary.*

For $n_A = 0$ the optimal knowledge investment of subsidiary A reads as:

$$x_A^* = (a_A - c_A) + (a_B - c_B)\varphi\beta_I \quad (4.16)$$

¹²See *supra*, chapter 2 of the present work.

Proof. For $\varphi \in [0, 1]$ and $\varphi \neq 0$, then $\frac{\partial x_A^*}{\partial \beta_I} = \varphi (a_B - c_B) > 0$. ■

Therefore, the higher the internal knowledge flows within the multinational company, the lower the costs of the focal subsidiary due to the fact that knowledge investment has a positive impact in the cost structure of the focal subsidiary and of the multinational company as a whole.

4.2.6 Specific knowledge under decentralized knowledge investment policy

Secondly, at the beginning of the present work the different typologies of knowledge in terms of sources and basic features have been investigated¹³. The two subsidiaries A and B play a crucial role under decentralized knowledge investment policy since they are in charge of knowledge production and development for the multinational company as a whole. Moreover, it has been assumed that the knowledge produced is locally embedded and context-specific. Therefore, it can be further assumed that this kind of knowledge is hardly transferable to other units, that is to say $\varphi = 0$.

For $n_A = 0$ (no competitors in market A) and $\varphi = 0$ (hardly transferable context-specific knowledge) profits reads as:

$$\Pi_A^d = \frac{(2(a_A - c_A))^2 - 2b_A(a_A - c_A)^2}{4b_A} = \frac{(a_A - c_A)^2(4 - 2b_A)}{4b_A} \quad (4.17)$$

Equation (4.17) will be further of interest when comparing it with the profits under centralized knowledge investment policy (scenario 2) and implying general knowledge production from the headquarter.

4.3 Scenario 2: centralized knowledge investment policy

Contrasting to the previous scenario 1, the central headquarter is the main actor within the centralized knowledge investment scenario. In fact, knowledge investments are conducted centrally without any involvement from subsidiary A or B. The headquarter is not located

¹³ See *supra*, section 2.2.4 of the present work.

in the markets/countries of reference of its subsidiaries A and B and invests in general "internal knowledge", which can be easily transferred within the MNC (Foss and Pedersen, 2002) and is not of relevance for the external market. As a consequence, external spillovers β_E can only be absorbed from the two subsidiaries in their respective markets and no external knowledge flows arise from the subsidiaries towards their external environment since they are not participating to the knowledge investment process. Moreover, internal spillovers β_I take place respectively between subsidiary A and the HQ as well as subsidiary B and the HQ due to the organizational structure of the multinational company without any activity from the subsidiaries.

4.3.1 Effective knowledge investments under centralized knowledge investment policy

The knowledge investments the headquarter faces when centralizing R&D efforts are defined as x_H since it has been assumed that no external spillovers (from the MNC to the external market) are to be recognized in the case of R&D centralization. Furthermore, the subsidiaries are not actively involved in the R&D policy of the MNC but enjoy $\beta_I x_H$ internal spillovers from the R&D investment conducted by the headquarter. External spillovers coming from the knowledge investment activities of the competitors in the relevant market take place as in the decentralization case elucidated in the section above.

The effective R&D investments in market A and B, respectively of subsidiaries and competitors, are the following:

$$X_A^c = \varphi \beta_I x_H + \beta_E \sum_{a=1}^{n_A} x_a \quad (4.18)$$

$$X_B^c = \varphi \beta_I x_H + \beta_E \sum_{b=1}^{n_B} x_b \quad (4.19)$$

Both subsidiaries A and B are not actively participating to the knowledge production process. Therefore, they are only receiving internal knowledge spillovers from the

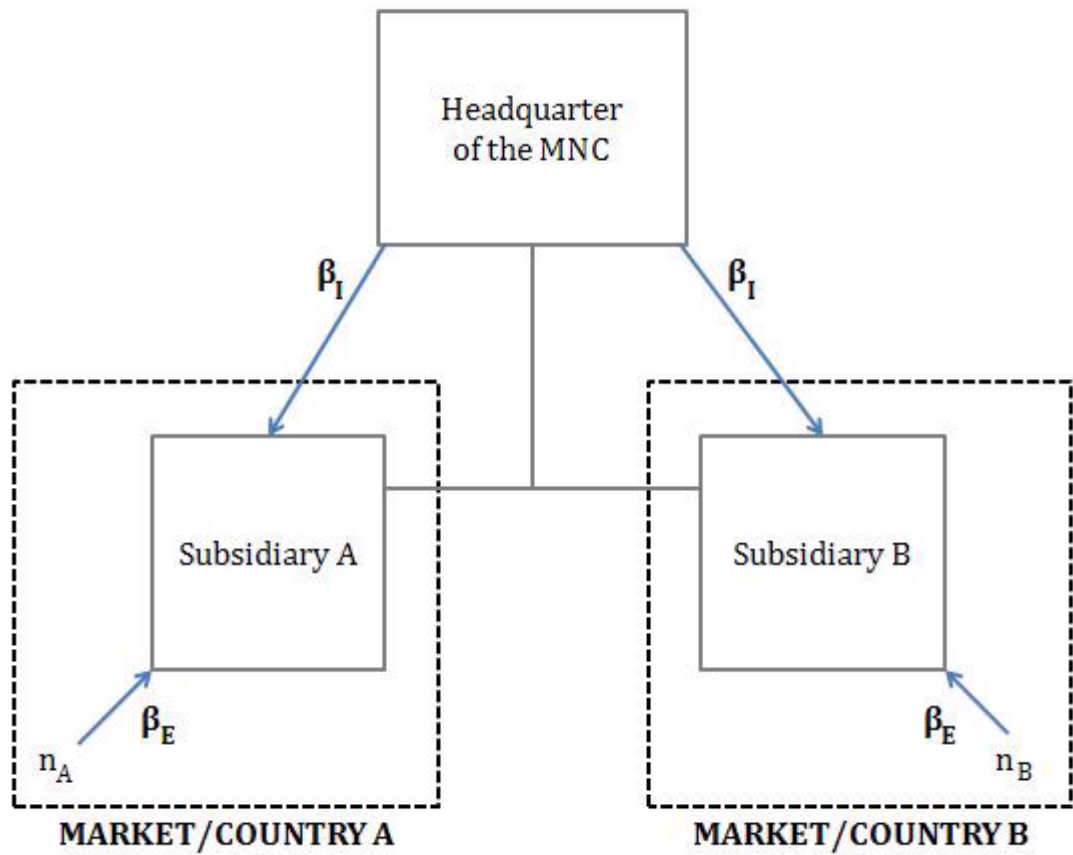


Figure 4.3: Structure of the MNC and knowledge spillovers under centralized knowledge production (own representation)

headquarter, defined as $\varphi\beta_I x_H$, as well as external spillovers from their own market of reference, e.g. $\beta_E \sum_{a=1}^{n_A} x_a$ from all the competitors in market A. Once again, φ captures the complementarity between products (or production processes) in market A and B.

The effective knowledge investment of the headquarter reads as:

$$X_H^c = x_H + 2\varphi\beta_I x_H + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \sum_{b=1}^{n_B} x_b \quad (4.20)$$

The headquarter has its own knowledge efforts defined as x_H , sends some internal knowledge spillovers $2\varphi\beta_I x_H$ to both subsidiaries A and B and absorbs the external spillovers coming from market A and B, defined respectively as $\beta_E \sum_{a=1}^{n_A} x_a$ in market A and $\beta_E \sum_{b=1}^{n_B} x_b$ in market B.

The knowledge investment policy of the multinational company has an effect on the external environment as well. In fact, the competitors in both markets A and B cannot profit from knowledge spillovers coming from the multinational company. Therefore, they are investing on their own for x_i in market A and x_j in market B and enjoying external spillovers only from each others, e. g. defined as $\beta_E \sum_{a=1}^{n_A} x_a$ in market A.

$$X_i^c = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a = (1 - \beta_E) x_i + \beta_E \sum_{a=1}^{n_A} x_a \quad (4.21)$$

$$X_j^c = x_j + \beta_E \sum_{b=1, b \neq j}^{n_B} x_b = (1 - \beta_E) x_j + \beta_E \sum_{b=1}^{n_B} x_b \quad (4.22)$$

4.3.2 Cost functions under centralized knowledge investment policy

The cost functions of the subsidiaries as well as of their competitors in market A and B may be derived as follows. Once again aim knowledge investments at reducing costs.

$$C_A^c(q_A, X_A) = (c_A - X_A^c)q_A = (c_A - \varphi\beta_I x_H - \beta_E \sum_{a=1}^{n_A} x_a)q_A \quad (4.23)$$

$$C_B^c(q_B, X_B) = (c_B - X_B^c)q_B = (c_B - \varphi\beta_I x_H - \beta_E \sum_{b=1}^{n_B} x_b)q_B \quad (4.24)$$

$$C_i^c(q_i, X_i) = (c_i - X_i^c)q_i = \left(c_i - \left((1 - \beta_E)x_i + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_i \quad (4.25)$$

$$C_j^c(q_j, X_j) = (c_j - X_j^c)q_j = \left(c_j - \left((1 - \beta_E)x_j + \beta_E \sum_{b=1}^{n_B} x_b \right) \right) q_j \quad (4.26)$$

4.3.3 Profit maximization functions and optimal output under centralized knowledge investment policy

The profit maximization functions of the subsidiaries A and B are displayed in the following equations. The assumption of quadratic costs applies¹⁴.

$$\max_{q_A} \pi_A^c = \max \left(a_A - b_A \left(\sum_{a=1, a \neq i}^{n_A} q_a + q_A \right) - (c_A - X_A^c) \right) q_A - \frac{x_H^2}{2} \quad (4.27)$$

$$\max_{q_B} \pi_B^c = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_B - X_B^c) \right) q_B - \frac{x_H^2}{2} \quad (4.28)$$

The other companies in market A and B display the following profit maximization functions:

$$\max_{q_i} \pi_i^c = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^c) \right) q_i - \frac{x_i^2}{2} \quad (4.29)$$

$$\max_{q_j} \pi_j^c = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_j - X_j^c) \right) q_j - \frac{x_j^2}{2} \quad (4.30)$$

Accordingly, the optimal quantities of subsidiary A and of all the other competitors on

¹⁴ See *supra*, Scenario 1.

market A can be derived¹⁵. As already specified above, all other firms in market A are identical, such that $q_i^* = q_a^*$.

$$q_a^{c*} = \frac{1}{b_A(n_A + 2)} (a_A - 2C_a^c + C_A^c) \quad (4.31)$$

$$q_A^{c*} = \frac{1}{b_A(n_A + 2)} (a_A - (n_A + 1)C_A^c + n_A C_a^c) \quad (4.32)$$

The profit of the MNC as a whole results as follows and is the sum of the profits of both subsidiary A and B

$$\begin{aligned} \Pi_H^{c*} &= \Pi_A^c + \Pi_B^c \quad (4.33) \\ \Pi_H^{c*} &= \frac{(a_A + n_A C_a^c - (n_A + 1)C_A^c)^2}{b_A(n_A + 2)^2} - \frac{x_H^2}{2} + \dots \\ &\quad + \frac{(a_B + n_B C_b^c - (n_B + 1)C_B^c)^2}{b_B(n_B + 2)^2} - \frac{x_H^2}{2} \end{aligned}$$

4.3.4 Optimal knowledge investments under centralized knowledge investment policy

Once the profit functions are known, the optimal knowledge investment quantities may be derived as follows¹⁶ (respectively for the competitors in market A and B as well as for the headquarter).

¹⁵For the calculations related to market B (subsidiary B and its competitors) please refer to Appendix 2 at the end of the present work.

¹⁶For the proof of these equations please refer to Appendix 2 at the end of the present work.

$$x_a^{c*} = \frac{z_A (a_A - c_A) (2t_B z_B \varphi \beta_I - 1)}{(\varphi \beta_I (2t_B z_B + t_A z_A z_H) - 1)} + \dots \quad (4.34)$$

$$+ \frac{z_A (2d_B + z_H (d_A + 2t_B z_B (a_B - c_B))) \varphi \beta_I}{(\varphi \beta_I (2t_B z_B + t_A z_A z_H) - 1)}$$

$$x_b^{c*} = \frac{z_B (a_B - c_B) (t_A z_A z_H \varphi \beta_I - 1)}{(\varphi \beta_I (2t_B z_B + t_A z_A z_H) - 1)} + \dots \quad (4.35)$$

$$+ \frac{z_B (2d_B + z_H (d_A - t_A z_A (a_A - c_A))) \varphi \beta_I}{(\varphi \beta_I (2t_B z_B + t_A z_A z_H) - 1)} \quad (4.36)$$

$$x_H^{c*} = \frac{2d_B - 2t_B z_B (a_B - c_B) + z_H (d_A - t_A z_A (a_A - c_A))}{(1 - \varphi \beta_I (2t_B z_B + t_A z_A z_H))} \quad (4.37)$$

4.3.5 Testing the definition of the multinational company under centralized knowledge investment policy

The same procedure, which has been applied to scenario 1 when testing the definition of the multinational company in terms of knowledge flows, applies to scenario 2. Once again the external environment will be reduced in order to focus on the internal flows within the multinational company, such that no competitors will be considered. Accordingly, $n_A = n_B = 0$.

Conclusion 3 *If no competitors are to be found in their respective markets A and B, then the higher the company internal spillovers, the higher the profits of the MNC.*

For $n_A = n_B = 0$ the profits of the multinational company as a whole read as:

$$\Pi_H^c = \frac{((a_A - c_A) + \varphi \beta_I x_H)^2}{4b_A} + \frac{((a_B - c_B) + \varphi \beta_I x_H)^2}{4b_B} - x_H^2 \quad (4.38)$$

Proof. For $\varphi \in [0, 1]$ and $\varphi \neq 0$

$$\frac{\partial \Pi_H^c}{\partial \beta_I} = \left(\frac{\varphi x_H}{2b_A} \right)^2 + \left(\frac{\varphi x_H}{2b_B} \right)^2 > 0 \quad (4.39)$$

■

The optimal knowledge investment policy for the headquarter under the assumption that no competitors are active on market A and B is the following:

$$x_H^* = \left((a_A - c_A) + (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right) \quad (4.40)$$

Furthermore, assuming that no internal spillovers take place within the multinational company, that is to say, $\beta_I = 0$, the profits of the company as a whole may be derived as follows.

$$\Pi_H^c = \frac{4b_B (a_A - c_A)^2 + 4b_A (a_B - c_B)^2}{4b_A 4b_B} - \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2 \quad (4.41)$$

4.3.6 General knowledge under centralized knowledge investment policy

Within the decentralized knowledge investment policy it has been assumed that subsidiaries invest in specific knowledge thanks to their local embeddedness, such that $\varphi = 0$. On the contrary, within the centralized knowledge investment policy it will be assumed that the headquarter is investing in general knowledge of relevance for the whole multinational company, such that $\varphi = 1$. However, due to the fact that the two subsidiaries are by no means involved in these processes of knowledge creation and transfer, it will be assumed for the purpose of the present model that no internal spillovers take place within the multinational company, that is to say $\beta_I = 0$.¹⁷ Accordingly, following profit function of subsidiary A under centralized knowledge investment policy can be obtained.

¹⁷The assumptions underlying scenario 1 and scenario 2 are divergent. In scenario 1 (*see supra*) it has been assumed that the context-specific knowledge developed at the subsidiary level has the features of a private good, where $\varphi = 0$, that is to say, the (production) processes within market A and B are not at all complementary. As a consequence, no internal knowledge spillovers may be generated within the multinational company, since $\beta_I = 0$. In scenario 2 it has been assumed that the general knowledge developed at the headquarter level has the features of a public good, where $\varphi = 1$. However, due to the fact the subsidiary A and B are not involved in the central knowledge investment processes, they are not willing to participate to these knowledge flows, such that $\beta_I = 0$. This implies that both scenarios base on the same assumptions concerning internal spillovers, which have been derived from different perspectives due to the consideration of different knowledge features within the theoretical model.

For $\varphi = 1$ (general knowledge) and $\beta_I = 0$ (no willingness to participate to central knowledge flows) the profit of focal subsidiary A read as:

$$\Pi_A^c = \frac{(a_A - c_A)^2}{4b_A} - 2 \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2 \quad (4.42)$$

Aftering having derived the optimal profits and the optimal knowledge investment policy in scenario 2, the outcomes can be compared with those of scenario 2 within the previous section¹⁸.

Conclusion 4 *Comparing the profits of subsidiary A under decentralized knowledge production with the profits under centralized knowledge production under the same assumptions (no competitors in the market of reference as well as no internal knowledge flows - for divergent reasons elucidated within the lines above) it can be clarified that knowledge production decentralization is to be preferred to knowledge production centralization in terms of profits since:*

$$\Pi_A^c = \frac{(a_A - c_A)^2}{4b_A} - 2 \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2 < \Pi_A^d = \frac{(a_A - c_A)^2 (4 - 2b_A)}{4b_A} \quad (4.43)$$

Conclusion 5 *Comparing the optimal knowledge quantities under the assumption that no competitors are in the markets of reference and no internal spillovers take place within the multinational company, it can be explained that the decentralized knowledge production policy is much more knowledge intensive that the decentralized one:*

$$x_H^c = \frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} < x_H^d = x_A^d + x_B^d \quad (4.44)$$

¹⁸In order to allow for the comparison of scenario 1 with scenario 2 it has been assumed that the parameters of the model (i.e. a_A , b_A as well as c_A) are for both scenarios the same. In fact, the knowledge investment decision is taken at the headquarter level and only one decision (decentralization vs. centralization) will take place on the same markets of reference. Hence, those markets display within both scenarios the same features.

where $x_H^d = (a_A - c_A) + (a_B - c_B)$.

The results of the model are consistent with the international business and management literature according to which the headquarter has to face the so called "outsidership problem" (Vahlne *et al.*, 2012) due to the fact that it is not participating to the interactions with the external environment as subsidiaries do. Therefore, both knowledge intensity as well as profits are higher in scenario 1 under decentralized knowledge investment policy.

4.4 Scenario 3: HQ intervention within decentralized knowledge investment policy

In the previous analysis of knowledge investment decentralization the HQ was by no means involved. It has been demonstrated that in this case, under the assumption that the knowledge produced by the subsidiaries is specific and therefore difficult to be transferred within the multinational company, knowledge investment decentralization leads to higher profits than within knowledge investment centralization.

In the following, an active role played by the HQ in the decentralization is looked at. In fact, subsidiaries are internally embedded within the multinational company. Those subsidiaries, which are particularly active in knowledge investment and replication and that reach a high degree of innovations, capture the attention of the headquarter that may decide to support the knowledge activities of the focal subsidiary as well as involve itself in those activities (Ciabuschi *et al.*, 2011).

Following assumptions apply to the model. First of all, the HQ plays an active role in the decentralized knowledge production, i.e. the HQ delegates a portion α of knowledge production to be conducted from subsidiary A, which invests αx_A . Therefore, the HQ invests the remaining portion, $(1 - \alpha)(x_H - x_A)$, where x_H is the highest possible knowledge investment within the multinational company located at the headquarter level.

A significant assumption is also taken for what concerns the role played by subsidiary A. In fact, subsidiary A is a so called "centre of excellence", since it is highly specialized and recognized within the company for its role in knowledge production, deployment and

replication¹⁹. Therefore, it will be assumed that company internal spillovers are high, such that $\beta_I = 1$. For the same reasons, it has been assumed that also external spillovers are quite high, that is to say, $\beta_E = 1$, due to the fact that the superiority of the centre of excellence is well-known in the market and competitors recognize that. Moreover, some costs are to be incurred for competence transfer, which are as usual in the model included in φ . Finally, it is assumed that the spillovers absorption rate $\gamma_A \in [0, 1]$. Subsidiary B is not playing an active role within scenario 3 of the present model.

4.4.1 Effective knowledge investments assuming HQ intervention within decentralized knowledge investment policy

In the following, the effective knowledge investments have been derived. As has been already specified within some lines above, the headquarter invests only a portion $(1 - \alpha)$ of the whole knowledge investments at disposal to the multinational company. Moreover, the headquarter receives internal knowledge spillovers $\varphi\beta_I\alpha x_A$ from the knowledge investment activity conducted by subsidiary A as a centre of excellence. The effective knowledge investments of the headquarter look as follows:

$$X_H^{di} = (1 - \alpha)(x_H - x_A) + \varphi\beta_I\alpha x_A \quad (4.45)$$

Subsidiary A, as a centre of excellence, invests the knowledge portion α that has been delegated from the headquarter and receives internal knowledge spillovers from the knowledge investment activity conducted by the headquarter itself defined as $\varphi\beta_I(1 - \alpha)(x_H - x_A)$. Moreover, the centre of excellence is exchanging information with the external environment due to its well-known position, such that some external spillovers $\beta_E \sum_{a=1}^{n_A} x_a$ may be recognized as well.

¹⁹For further information about centre of excellence within the management and international business literature please refer to chapter 2 of the present work.

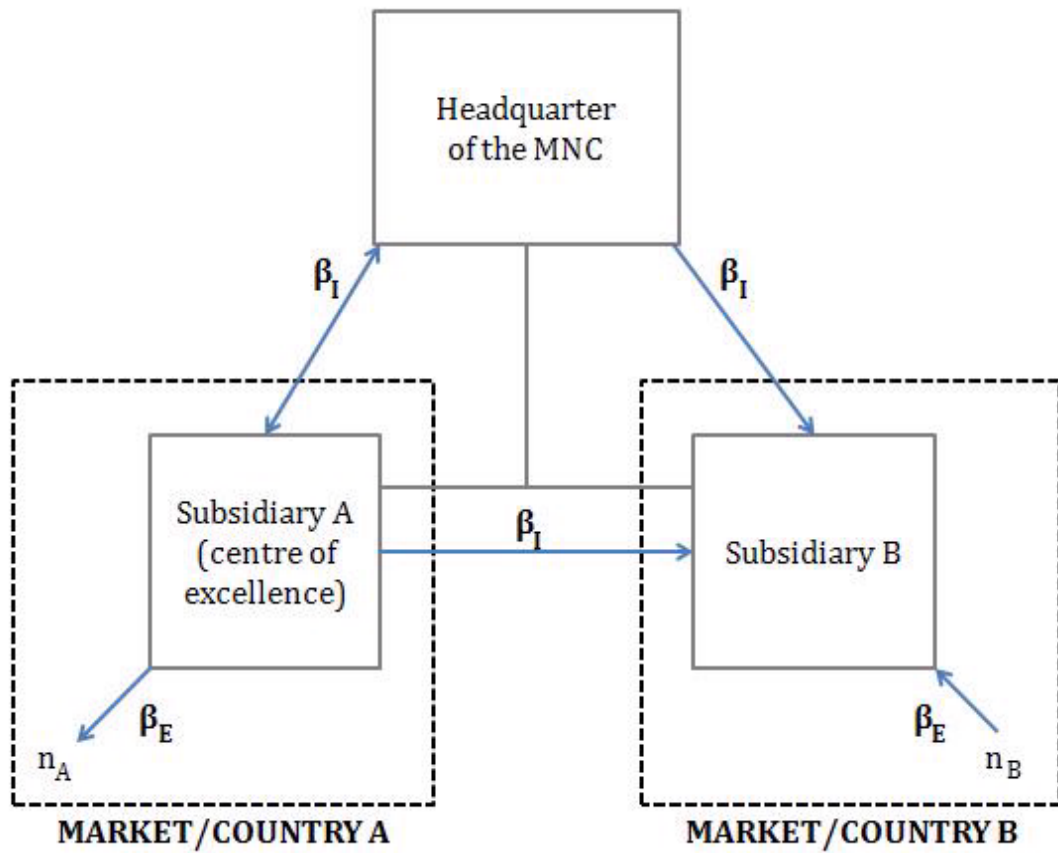


Figure 4-4: Structure of the MNC and knowledge spillovers under decentralized knowledge production and HQ intervention (own representation)

$$X_A^{di} = \alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a \quad (4.46)$$

Subsidiary B is not involved in the knowledge production processes und receives knowledge spillovers from the multinational company (respectively from the headquarter $\varphi \beta_I (1 - \alpha) (x_H - x_A)$) as well as from the centre of excellence involved in knowledge production with $\varphi \beta_I \alpha x_A$) as well as from its own external environment, such that

$$X_B^{di} = \varphi \beta_I (1 - \alpha) (x_H - x_A) + \varphi \beta_I \alpha x_A + \beta_E \sum_{b=1}^{n_B} x_b \quad (4.47)$$

The effective knowledge investments of all competitors in market A depend once again not only on their own knowledge investment, but also on the knowledge spillovers from the other competitors in the market as well as from the centre of excellence, subsidiary A.

$$X_i^{di} = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a + \beta_E \alpha x_A = (1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E \alpha x_A \quad (4.48)$$

Assuming that in market A $\beta_E = 1$ due to the recognized knowledge activities of the centre of excellence we can simplify as follows:

$$X_i^{di} = n_A x_i + \alpha x_A \quad (4.49)$$

4.4.2 Cost functions assuming HQ intervention within decentralized knowledge investment policy

The cost functions that can be observed are as follows. Once again, knowledge investments aim at diminishing production costs both within the multinational company as well as in the market A.

$$C_H^{di} (q_H, X_H^{di}) = (c_H - X_H) q_H = (c_H - ((1 - \alpha)(x_H - x_A) + \varphi\beta_I\alpha x_A)) q_H \quad (4.50)$$

$$C_A^{di} (q_A, X_A^{di}) = (c_A - X_A) q_A \quad (4.51)$$

$$= \left(c_A - \left(\alpha x_A + \varphi\beta_I(1 - \alpha)(x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_A$$

$$C_i^{di} (q_i, X_i^{di}) = (c_i - X_i) q_i \quad (4.52)$$

$$= \left(c_i - \left((1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E \alpha x_A \right) \right) q_i$$

4.4.3 Profit maximization functions and optimal output assuming HQ intervention within decentralized knowledge investment policy

As the cost functions are known, the profit maximization functions may be derived respectively for the centre of excellence A and for all the competitors on market A.

$$\max_{q_A} \pi_A = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_A - X_A^{di}) \right) q_A - \frac{x_H^2}{2} \quad (4.53)$$

$$\max_{q_i} \pi_i = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^{di}) \right) q_i - \frac{x_i^2}{2} \quad (4.54)$$

The optimal output quantities in market A look as follows²⁰:

$$q_A^{di*} = \frac{1}{b_A(n_A + 2)} \left(a_A - (n_A + 1) C_A^{di} + n_A C_a^{di} \right) \quad (4.55)$$

$$q_a^{di*} = \frac{1}{b_A(n_A + 2)} \left(a_A - 2C_a^{di} + C_A^{di} \right) \quad (4.56)$$

Hence, the profit function can be calculated respectively for the competitors on market A and for the centre of excellence:

²⁰For the proof of these equations please refer to Appendix 3 at the end of the present work.

$$\Pi_a^{di*} = \frac{(a_A + C_A^{di} - 2C_a^{di})^2}{b_A (n_A + 2)^2} - \frac{x_a^2}{2} \quad (4.57)$$

$$\Pi_A^{di*} = \frac{(a_A + n_A C_a^{di} - (n_A + 1) C_A^{di})^2}{b_A (n_A + 2)^2} - \frac{x_H^2}{2} \quad (4.58)$$

The profit function of the multinational company as a whole from the perspective of the headquarter is the sum of the profit functions of both subsidiaries A and B. As already specified some lines above, subsidiary B is not actively participating to the knowledge production processes, therefore no costs are associated with those investments.

$$\begin{aligned} \Pi_H^{di} &= \Pi_A^{di} + \Pi_B^{di} \quad (4.59) \\ \Pi_H^{di} &= \frac{(a_A + n_A C_a^{di} - (n_A + 1) C_A^{di})^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} + \dots \\ &\quad + \frac{(a_B + n_B C_b^{di} - (n_B + 1) C_B^{di})^2}{b_B (n_B + 2)^2} \end{aligned}$$

4.4.4 Optimal knowledge investments assuming HQ intervention within decentralized knowledge investment policy

Accordingly, the optimal knowledge quantities can be derived for the competitors in market A, for the centre of excellence A as well as for the headquarter of the multinational company²¹:

$$x_a^{di*} = z_a \left(d_a + r_a x_A - \frac{\varphi \beta_I (1 - \alpha)}{z_a} x_H \right) \quad (4.60)$$

$$x_A^{di*} = z_A \left(d_A + r_A x_a + \frac{(n_A \varphi \beta_I + \varphi \beta_I) (1 - \alpha)}{z_A} x_H \right) \quad (4.61)$$

$$x_H^{di*} = z_H ((a_A - c_A) + t_H x_a + s_H x_A + (a_B - c_B) + g_H x_b) \quad (4.62)$$

²¹For the proof of these equations please refer to Appendix 3 at the end of the present work.

4.4.5 Testing the definition of the multinational company assuming HQ intervention within decentralized knowledge investment policy

The starting point of analysis in both the precedent scenarios 1 and 2 has been the definition of the multinational company, according to which knowledge flows may be moved from the unit producing them from the unit where the highest profits can be generated. In order to test for this, the external environment should not be considered for a moment, that is to say, no competitors are assumed to be in both markets of reference A and B. Assuming that, i. e. $n_A = n_B = 0$ as already done for scenario 1 and 2, the following profit function may be derived for the centre of excellence:

$$\Pi_A^{di} = \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} \quad (4.63)$$

$$\begin{aligned} \Pi_A^{di} &= \frac{((a_A - c_A) + (\alpha + \varphi\beta_I\alpha - \varphi\beta_I) x_A + (\varphi\beta_I - \varphi\beta_I\alpha) x_H)^2}{4b_A} - \frac{x_A^2}{2} \\ &= \frac{((2 + 2(\alpha + \varphi\beta_I\alpha - \varphi\beta_I)) (a_A - c_A) + (a_B - c_B))^2}{4b_A} + \dots \end{aligned} \quad (4.64)$$

$$- \left((a_A - c_A) + 2(a_B - c_B) \left(\frac{\varphi\beta_I(1 - \alpha)}{(1 - (\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha)\varphi\beta_I(1 - \alpha))} \right) \right)^2 \quad (4.65)$$

The optimal knowledge investment of the centre of excellence A is as follows:

$$x_A^* = 2(a_A - c_A) + (a_B - c_B) \left(\frac{\varphi\beta_I(1 - \alpha)}{(1 - (\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha)\varphi\beta_I(1 - \alpha))} \right) \quad (4.66)$$

Assuming that $\beta_I = 1$, following result can be obtained:

$$x_A^{di*} = 2(a_A - c_A) + (a_B - c_B) \left(\frac{\varphi(1 - \alpha)}{(1 - (\alpha - 2\varphi + \varphi\alpha)\varphi(1 - \alpha))} \right) \quad (4.67)$$

The same reasoning applies to the headquarter that displays the following profit function:

$$\begin{aligned}
\Pi_H^{di} &= \frac{(a_A - (c_A - (\alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A))))^2}{b_A (n_A + 2)^2} + \dots \\
&+ \frac{(a_B - (c_B - (\varphi \beta_I \alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A))))^2}{b_B (n_B + 2)^2} + \dots \\
&- \frac{x_A^2}{2}
\end{aligned} \tag{4.68}$$

The optimal knowledge investment of the headquarter under the assumption that no competitors are active on market A and B is the following:

$$\begin{aligned}
x_H^* &= (a_A - c_A) \frac{(1 - (\alpha - 2\varphi \beta_I + \varphi \beta_I \alpha))}{(1 - (\alpha - 2\varphi \beta_I + \varphi \beta_I \alpha) \varphi \beta_I (1 - \alpha))} + \dots \\
&+ (a_B - c_B) \frac{1}{(1 - (\alpha - 2\varphi \beta_I + \varphi \beta_I \alpha) \varphi \beta_I (1 - \alpha))} \\
&= \frac{(a_A - c_A) (1 - (\alpha - 2\varphi \beta_I + \varphi \beta_I \alpha)) + (a_B - c_B)}{(1 - (\alpha - 2\varphi \beta_I + \varphi \beta_I \alpha) \varphi \beta_I (1 - \alpha))}
\end{aligned} \tag{4.69}$$

Simplifying once again due to $\beta_I = 1$:

$$x_H^* = \frac{(a_A - c_A) (1 - (\alpha - 2\varphi + \varphi \alpha)) + (a_B - c_B)}{(1 - (\alpha - 2\varphi + \varphi \alpha) \varphi (1 - \alpha))} \tag{4.70}$$

Once again, internal spillovers β_I are crucial for both profits and knowledge investment policy of the multinational company as a whole. However, another crucial parameter in this specific case within scenario 3 is the delegation factor α . Therefore, the optimal knowledge delegation factor should be derived.

4.4.6 The role of the centre of excellence assuming HQ intervention within decentralized knowledge investment policy

Aim of scenario 3 is that of combining an active role by the headquarter (in terms of delegation and active knowledge production) with a decentralized knowledge production policy

(within the centre of excellence played by subsidiary A). At the beginning of the present section it has been assumed that the headquarter has three main delegation decisions:

1. the headquarter can completely delegate knowledge production for $\alpha = 1$,
2. The headquarter can exclusively invest in knowledge production without any form of delegation to the subsidiary level for $\alpha = 0$.
3. The headquarter can delegate a defined portion to be conducted by the centre of excellence A for $0 < \alpha < 1$.

In the following, these three decisions are looked at.

4.4.7 Without knowledge investment delegation

Assuming $\alpha = 0$, then the headquarter is exclusively investing in knowledge production without delegating any portion to the centre of excellence. Hence, the optimal knowledge production quantities respectively of the headquarter and of the centre of excellence A look as follows:

$$x_H^* = \frac{(a_A - c_A)(1 - 2\varphi) + (a_B - c_B)}{(1 + 2\varphi^2)} \quad (4.71)$$

$$x_A^* = 2(a_A - c_A) + (a_B - c_B) \left(\frac{\varphi}{(1 + 2\varphi^2)} \right) \quad (4.72)$$

Therefore, this specific case may be compared with the results of the centralized knowledge investment policy of section 4.3²².

²²In order to allow for the comparison of scenario 3 with scenarios 1 and 2 it has been assumed that the parameters of the model (i.e. a_A , b_A as well as c_A) are for the three scenarios the same. In fact, the knowledge investment decision is taken at the headquarter level and only one decision (out of decentralization, centralization or delegation of (a part of) the knowledge investment process) will take place on the same markets of reference. Hence, those markets display within the three scenarios the same features.

$$x_H^c = \frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} > x_H^{di*} = \frac{(1 - 2\varphi)(a_A - c_A) + (a_B - c_B)}{(1 + 2\varphi^2)} \quad (4.73)$$

$$x_H^d = (a_A - c_A) + (a_B - c_B) > x_H^{di*} = \frac{(1 - 2\varphi)(a_A - c_A) + (a_B - c_B)}{(1 + 2\varphi^2)} \quad (4.74)$$

Conclusion 6 *Assuming that the headquarter is exclusively generating knoweldge for the entire multinational company without any intervention from the centre of excellence and from subsidiary B, then the decentralized knowledge investment policy (scenario 1) is much more knowledge intensive than both scenario 2 and 3 since both $\frac{4b_A 4b_B + 1}{4b_A 4b_B} \neq 1$ and $\frac{(1-2\varphi)+1}{(1+2\varphi^2)} \neq 1$.*

Conclusion 7 *For $\varphi \neq 0$ and $\frac{4b_A 4b_B + 1}{4b_A 4b_B} > \frac{(1-2\varphi)+1}{(1+2\varphi^2)}$, where $0 \leq \varphi \leq 1$, then the centralized knowledge investment policy is generating more knowledge, and therefore more profits, than the exclusive knowledge production by the headquarter within the decentralized scenario 3.*

Conclusion 8 *Delegation of (a portion of) knowledge production to the centre of excellence will always generate more profits under the above mentioned assumptions than without any kind of delegation mechanisms. Therefore, the headquarter has an intrinsic incentive to delegate.*

The main results in absence of delegation to the centre of excellence are consistent to the international management literature according to which "[...] headquarter managers not only have incomplete knowledge of structures and processes taking place within the MNC, but often do not even know what they need to know" (Ciabuschi *et al.*, 2012: 218). This can be clearly seen within this scenario since, even though the option to delegate a knowledge production portion to the centre of excellence A is given, the headquarter is engaging itself in knowledge production without considering the poor performance out of this investment.

4.4.8 Within fully knowledge investment delegation

On the contrary, assuming that $\alpha = 1$, that is to say, that the centre of excellence has been delegated the whole knowledge production, the optimal knowledge production quantities may be derived as well.

$$x_H^{di*} = \varphi(a_A - c_A) + (a_B - c_B) > x_H^c = \frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \quad (4.75)$$

$$x_H^d = (a_A - c_A) + (a_B - c_B) > x_H^{di*} = \varphi(a_A - c_A) + (a_B - c_B) \quad (4.76)$$

The same comparison can be done at the subsidiary level, taking into consideration the amount of knowledge investment by subsidiary A under the three scenarios.

$$x_A^{di*} = 2(a_A - c_A) > x_A^{d*} = (a_A - c_A) \quad (4.77)$$

Conclusion 9 For $\varphi \neq 0$ and $(\varphi + 1) > \frac{4b_A 4b_B + 1}{4b_A 4b_B}$, where $0 \leq \varphi \leq 1$, then the entire delegation of knowledge production from the headquarter to the centre of excellence (i.e. $\alpha = 1$), is more knowledge intensive than the centralized knowledge investment policy (scenario 1), is more knowledge intensive than the decentralized knowledge investment policy (scenario 2).

Conclusion 10 For $\varphi \neq 0$ and $\varphi = 1$, where $0 \leq \varphi \leq 1$, then the entire delegation of knowledge production from the headquarter to the centre of excellence (i.e. $\alpha = 1$), is as knowledge intensive as the decentralized knowledge investment policy (scenario 1). This would imply that no costs are associated with the knowledge transfer from the centre of excellence to the other units of the multinational company and that the knowledge produced by subsidiary A as a centre of excellence is a public good.

Conclusion 11 Assuming that the centre of excellence is exclusively generating knowledge for the entire multinational company without any intervention from the headquarter and from subsidiary B, then the centre of excellence is generating twice the knowledge amount produced by subsidiary A within decentralization.

The same analysis can be conducted for what concerns the profits of the multinational company, which are on the following displayed respectively for HQ intervention within decentralization (scenario 3), for the centralized knowledge investment policy (scenario 2) as well as for the decentralized knowledge investment policy (scenario 1).

$$\Pi_H^{di} = \frac{(a_A - c_A)^2 \left((3 + 2\varphi)^2 - 8b_A \right) + (a_B - c_B)^2}{4b_A} \quad (4.78)$$

$$\Pi_H^c = \frac{(4b_A 16b_B^2 - 16b_A^2 16b_B^2) (a_A - c_A)^2 + (16b_A^2 4b_B - 1) (a_B - c_B)^2}{(4b_A 4b_B)^2} \quad (4.79)$$

$$\Pi_H^d = \frac{4b_B (4 - 2b_A) (a_A - c_A)^2 + 4b_A (4 - 2b_B) (a_B - c_B)^2}{4b_A 4b_B} \quad (4.80)$$

Conclusion 12 For $\frac{((3+2\varphi)^2-8b_A)+1}{4b_A} > \frac{(4b_A 16b_B^2 - 16b_A^2 16b_B^2 + 16b_A^2 4b_B - 1)}{(4b_A 4b_B)^2}$, then the entire delegation of knowledge production from the headquarter to the centre of excellence (i.e. $\alpha = 1$) generates higher profits than the centralized knowledge investment policy (scenario 2).

Conclusion 13 For $\frac{((3+2\varphi)^2-8b_A)+1}{4b_A} > \frac{4b_B(4-2b_A)+4b_A(4-2b_B)}{4b_A 4b_B}$, then the entire delegation of knowledge production from the headquarter to the centre of excellence (i.e. $\alpha = 1$) generates higher profits than the decentralized knowledge investment policy (scenario 1).

Some profits considerations can be done also at the subsidiary level, that is to say, looking at the profits of subsidiary A under decentralized knowledge investment policy as well as at the profits of the centre of excellence within scenario 3.

$$\Pi_A^d = \frac{(a_A - c_A)^2 (4 - 2b_A)}{4b_A} < \Pi_A^{di} = (a_A - c_A)^2 \quad (4.81)$$

Conclusion 14 For $\frac{(4-2b_A)}{4b_A} < 1$, then the profits generated by subsidiary A acting as centre of excellence and exclusively developing and deploying knowledge within the whole multi-

national company are higher than the profits generated by subsidiary A under decentralized knowledge investment policy.

4.4.9 Optimal knowledge investment delegation assuming HQ intervention within decentralized knowledge investment policy

After having considered the rand cases of α , the optimal α can be derived as well²³.

$$\alpha^* = z_\alpha \left((a_A - c_A) + (\beta_E n_A (\gamma_A + 1) + \beta_E n_A^2 (\gamma_A - 1) - n_A) x_a \right) - \frac{x_A^2}{2} b_A (n_A + 2)^2 \quad (4.82)$$

Assuming that no competitors are present in the market A and B, that is to say $n_A = n_B = 0$, α^* can be further simplified:

$$\alpha^* = (a_A - c_A) - 2b_A x_A^2 \quad (4.83)$$

Therefore, the optimal knowledge production delegation factor α depends on the knowledge investment conduct of the centre of excellence A.

Once the optimal α is known, the profit of the multinational company as a whole may be derived. However, in order to compare the profits originated from scenario 3 with those of the other two scenarios, similar assumptions should be derived in order to allow for that comparison. It has already been assumed that the knowledge produced from the centre of excellence is well-known in the external market, such that $\beta_E = 1$, as well as of immediate company internal-use, such that $\beta_I = 1$. For simplicity, we now assume that some costs are involved with the internal knowledge transfer, such that $\varphi = 0$ ²⁴.

As a consequence, the following optimal knowledge investments can be derived respectively for the centre of excellence A²⁵ as well as for the headquarter:

²³For the proof of this outcome please refer to Appendix 3 at the end of the present work.

²⁴*See supra*. This is consistent with the assumption made within scenario 1 where the knowledge produced by the two subsidiaries has been supposed to be locally embedded and context-specific.

²⁵*See supra*. The optimal knowledge investment of subsidiary A acting as a centre of excellence under

$$x_A^{di*} = 2(a_A - c_A) \quad (4.84)$$

$$x_H^{di*} = (a_A - c_A) \left(1 - (a_A - c_A) + 4b_A (a_A - c_A)^2 \right) + (a_B - c_B) \quad (4.85)$$

Conclusion 15 For $\varphi = 0$, then the delegation of a knowledge production portion from the headquarter to the centre of excellence is more knowledge intensive than the decentralized and centralized policies since $x_H^{di*} > x_H^c$, where $x_H^c = \frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B}$, and $x_H^{di*} > x_H^d$, where $x_H^d = (a_A - c_A) + (a_B - c_B)$.

The profits of the multinational company assuming HQ intervention within a decentralized knowledge investment policy look as follows:

$$\begin{aligned} \Pi_H^{di} &= \frac{((a_A - c_A) + (a_B - c_B) + \alpha x_A)^2}{4b_A} - \frac{x_A^2}{2} \quad (4.86) \\ &= \frac{((a_A - c_A) + (a_B - c_B) + ((a_A - c_A) - 2b_A x_A^2) (2(a_A - c_A)))^2 - 8b_A (a_A - c_A)^2}{4b_A} \\ &= \frac{((a_A - c_A) (1 + 2(a_A - c_A) (1 - 8b_A (a_A - c_A))) + (a_B - c_B))^2 - 8b_A (a_A - c_A)^2}{4b_A} \end{aligned}$$

Conclusion 16 For $\varphi = 0$, then the delegation of a knowledge production portion from the headquarter to the centre of excellence generates higher profits than the decentralized and centralized policies since $\Pi_H^{di} > \Pi_A^c$, where $\Pi_A^c = \frac{(a_A - c_A)^2}{4b_A} - 2 \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2$, and $\Pi_H^{di} > \Pi_A^d$, where $\Pi_A^d = \frac{(a_A - c_A)^2 (4 - 2b_A)}{4b_A}$.

4.5 Main results of the model

In order to investigate the main research question presented at the beginning of the present work, a theoretical model has been developed. The main results of the model can be sub-

the assumption that the knowledge produced has the feature of a private good, i. e. $\varphi = 0$, is the same as under fully knowledge delegation from the headquarter towards the subsidiary, where $\alpha = 1$.

sumed as follows. First of all, a decentralized knowledge investment policy, in which one or more subsidiaries are involved, is in general to be preferred to a centralized policy conducted merely at the headquarter level in terms of knowledge produced and profits generated. Secondly, should the headquarter have the option to delegate a part of the knowledge production process to a highly specialized subsidiary, this policy would generate a larger amount of knowledge and higher profit than without any kind of delegation procedure. Thirdly, the portion of knowledge to be delegated to the subsidiary should be accurately chosen in order for the multinational company to remain competitive on the market.

Managerial implication out of the model as well as suggestions for further reasearch are to be find in the last chapter 5 at the end of the present work.

Chapter 5

Conclusions and Recommendations

The last chapter of the present work is devoted to the summary of the main conclusions as well as to recommendations for further research. In the first section, the main results of the theoretical model elaborated within chapter 4 of the present work will be summarized. These will also be compared to the main findings and stream of thoughts within the international management literature. Furthermore, the limitation of the work will be elucidated as well. These will cover the structure of the model as well as the findings of the model. Finally, recommendations for further research in terms of other research methods to be used for investigating the same research questions of the present work will be discussed.

5.1 Summary of the main results and managerial implications

The main findings of the present work provide answers to the research question, whether the headquarter should invest itself in knowledge and then diffuse it within the whole multinational company or whether subsidiaries should be involved as well within these processes. The peculiarity of the model provides an economic view on an international management topic, which is not usually approached with economic (theoretical) models. That is to say, the theoretical approach is quite new to the international business literature and provide answers to many aspects in this research field.

First of all, the present work has positively tested the valued-added of the multinational company organizational structure defined in the international management literature as the generation of a considerable competitive advantage "from orchestrating knowledge flows between MNC units in such a way that knowledge is transferred to those MNC units where

it will increase value-added" (Foss and Pedersen, 2002: 54).

Secondly, the model has proved that subsidiaries participation in knowledge production generates higher profits than central knowledge production from the headquarter. This is consistent to the literature on subsidiaries' roles and autonomy within the multinational company ("autonomous initiative" according to Birkinshaw *et al.*, 1998; Forsgren *et al.*, 2000; Foss and Pedersen, 2002; Gupta and Govindarajan, 1991; Rugman and Verbeke, 2001).

Thirdly, it has been also proved that much more knowledge is generated under the knowledge decentralized investment policy, which has a favorable effect on the cost structure of the multinational company. This is also consistent with the management literature according to which some knowledge-intensive subsidiaries having access to specialized resources may be given some bargaining power and some additional autonomy, which cannot be easily revoked (Mudambi and Navarra, 2004)¹. Moreover, the knowledge intensity may be connected to the embeddedness of the subsidiaries in the external environment, which has been modeled taking into consideration external spillovers β_E .

Furthermore, a considerable contribution to the literature arises from involving the nature of different knowledge stocks within the model. In fact, the model was able to consider the peculiarities of specific knowledge generated from the subsidiaries (the so called "knowledge transfer" according to Mudambi and Navarra, 2004; Björkman *et al.*, 2004; context-specific "network-based" or "cluster-based" knowledge according to Foss and Pedersen, 2002) within the decentralized knowledge investment policy of scenario 1, general knowledge from the headquarter (knowledge internally developed according to Foss and Pedersen, 2002: 51) within centralized knowledge investment policy of scenario 2 as well as the peculiarities of the centre of excellence in terms of knowledge generation and diffusion not only within the multinational company but also within the industry involved in scenario 3, where the HQ intervention within a decentralized knowledge investment policy was looked at.

Once the main results of the model have been summarized, some managerial impli-

¹See *supra*, chapter 2.

cations may be derived from the model as well. In fact, the regionalization of knowledge development, in some cases even overseas, is quite a diffused organizational form nowadays. A study conducted by the consultancy company Oliver Wyman (2015) on the allocation of R&D activities by non-US automobile manufacturers shows that "over the past several decades, all major non-US automobile manufacturers have established fully functional regional research and development centers in North America" (2015: 18). Development responsibility is either directly allocated to the regional centre or remains central at the global headquarter. Moreover, automobile manufacturers make use of expatriates in key position at the very beginning of the regionalization process, but allocate major responsibility to local employees after the establishment of the local centre. This practices are consistent to the streams of literature analysed within chapter 2 of the present work² as well as with the main assumption underlying the theoretical model, especially within scenario 3 where the headquarter delegates a knowledge portion to be conducted abroad. The move toward regional responsibility has also been practiced from VW, which subsumed the twelve major brands of the company within four "groups" that have the power to take strategic decisions without involvement of the global headquarter, i.e. about which markets that should be entered in³.

On the other hand, current developments in the management practice recognize the crucial role played by active headquarter intervention, also after an already taken regionalization decision. This phenomenon is also known as 'reshoring' and consists in the moving of production activities away from the regional market, where they have been established due to lower production costs, back to the home country thanks to synergies arising from process automatization. However, activities from knowledge-intensive subsidiaries are mostly not affected from reshoring. To sum up, it can be seen that the participation of subsidiaries abroad to the knowledge processes of relevance for the multinational company as a whole is a quite widespread practice nowadays, sustaining the main finding of the present work.

² See *supra*, section 2.4.1.

³ *Handelsblatt*, 15.06.2015.

5.2 Limitations of the work and recommendations for further research

After having summarized the main findings of the present work and the managerial implications that can be derived accordingly, some limitations have to be mentioned as well. Those limitations are related to the structure of the model, to the assumptions related to the main findings as well as to the existence of other research methods that may investigate the analysed research question.

5.2.1 Limitations of the model

First of all, the set up of the developed theoretical model concerning the structure of the multinational company has been simplified. It has been assumed that the multinational company object of analysis has a headquarter and two subsidiaries abroad. The model may be extended to multinational firms, whose presence abroad is extended to more than two subsidiaries.

Secondly, for simplicity it has also been assumed that external spillovers β_E subsumed both ingoing and outgoing spillovers with regards to the multinational company. A specification of the flows direction may be of interest for further research on this topic. Directionality of knowledge transactions has not been investigated within the model of the present work and may be of relevance when analyzing subsidiary embeddedness and participation to knowledge flows.

5.2.2 Recommendations for further research

Further research on strategic knowledge interactions within multinational companies may be also conducted following other research methods. The presented theoretical model may be tested empirically in order to further stress the main findings. Moreover, the strategic knowledge flows within a multinational company having subsidiaries abroad may be investigated with the use of network theory. In this case, the role of subsidiaries and headquarters within the knowledge production and diffusion processes may be elucidated

e.g. in terms of centrality and power. Moreover, the effectiveness of knowledge production and diffusion may be measured as well. The supposed centrality of a centre of excellence within the whole multinational company may be critically discussed too.

Chapter 6

Appendix 1 - Scenario 1

The decentralized knowledge investment policy is modeled within scenario 1. Subsidiary A as well as its competitors in the same market A are the relevant actors. The effective knowledge investments under decentralized knowledge investment policy depend for all the actors on their own knowledge investments as well as on the investments of the other relevant actors in the market. Subsidiary A is part of the MNC, such that it is also influenced from the knowledge investment behavior of subsidiary B due to their belonging to the same company.

$$X_A^d = x_A + \varphi\beta_I x_B + \beta_E \sum_{a=1}^{n_A} x_a \quad (6.1)$$

All the other firms in market A are as a consequence influenced from the knowledge investment of subsidiary A.

$$X_i^d = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a + \beta_E x_A = (1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A \quad (6.2)$$

As already specified some lines above, knowledge investments aim at reducing costs both of the subsidiary involved as well as of the competitors in the relevant market. This can be seen within the relevant cost functions.

$$C_A^d(q_A, X_A^d) = (c_A - X_A^d) q_A = \left(c_A - \left(x_A + \varphi\beta_I x_B + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_A \quad (6.3)$$

$$C_i^d(q_i, X_i^d) = (c_i - X_i^d) q_i = \left(c_i - \left((1 - \beta_E) x_i + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A \right) \right) q_i \quad (6.4)$$

Both subsidiary A as the competitors in market A maximize their profits according to the following profit maximization functions.

$$\max_{q_A} \pi_A^d = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_A - X_A^d) \right) q_A - \frac{x_A^2}{2} \quad (6.5)$$

For another firm $i = 1, \dots, n_A$ on the market A or firm $j = 1, \dots, n_B$ on the market B profits read as follows:

$$\max_{q_i} \pi_i^d = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^d) \right) q_i - \frac{x_i^2}{2} \quad (6.6)$$

6.1 Proof of equations (4.7) and (4.8)

In order to obtain the optimal output set by both subsidiary A and its competitors, we take the FOC of the profit maximization functions explains above.

$$\frac{\partial \pi_A}{\partial q_A} = a_A - 2b_A q_A - b_A \sum_{a=1}^{n_A} q_a - (c_A - X_A^d) = 0 \quad (6.7)$$

$$q_A^* = \frac{1}{2b_A} (a_A - c_A + X_A^d - b_A n_A q_i) \quad (6.8)$$

Substituting $\Gamma_A = (c_A - X_A^d)$

$$q_A^* = \frac{1}{2b_A} (a_A - \Gamma_A - b_A n_A q_i) \quad (6.9)$$

The FOC applies also to the competitors in the market A.

$$\begin{aligned} \frac{\partial \pi_i}{\partial q_i} = & a_A - b_A \sum_{a=1, a \neq i}^{n_A} q_a - 2b_A q_i - b_A q_A - c_i + x_i + \dots \\ & -\beta_E x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E x_A \end{aligned} \quad (6.10)$$

Solving for q_i^* we obtain:

$$\begin{aligned} q_i^* &= \frac{1}{2b_A} \left(a_A - c_i + x_i - \beta_E x_i - b_A q_A - b_A \sum_{a=1, a \neq i}^{n_A} q_a + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E x_A \right) \\ &= \frac{1}{2b_A} \left(a_A - c_i + x_i - \beta_E x_i - b_A q_A - b_A (n_A - 1) q_i^* + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E x_A \right) \\ &= \frac{1}{b_A (n_A + 1)} \left(a_A - c_i - b_A q_A + x_i - \beta_E x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E x_A \right) \\ &= \frac{1}{b_A (n_A + 1)} \left(a_A - b_A q_A - (c_i - X_i^d) \right) \end{aligned} \quad (6.11)$$

Substituting $\Gamma_i = (c_i - X_i^d)$

$$q_a^* = \frac{1}{b_A (n_A + 1)} (a_A - \Gamma_a - b_A q_A) \quad (6.12)$$

Therefore, the optimal output of subsidiary A and of all the other competitors in market A look as follows. All other firms in market A are identical, such that $q_i^* = q_a^*$

$$q_a^* = \frac{1}{b_A (n_A + 2)} (a_A - 2C_a + C_A) \quad (6.13)$$

$$q_A^* = \frac{1}{b_A (n_A + 2)} (a_A - (n_A + 1) C_A + n_A C_a) \quad (6.14)$$

Considering the cost functions defined at the beginning of this appendix within the already known profit functions, we can obtain the optimal knowledge investments of subsidiary A as well as of its competitors in market A.

$$\begin{aligned}
\Pi_a^d &= \frac{(a_A + C_A - 2C_a)^2}{b_A (n_A + 2)^2} - \zeta_A \frac{x_a^2}{2} \\
&= \frac{(a_A + (c_A - (x_A + \varphi\beta_I x_B + \beta_E \sum_{i=1}^{n_A} x_i)))^2}{b_A (n_A + 2)^2} + \dots \\
&\quad - \frac{(2(c_A - ((1 - \beta_E) x_a + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A)))^2}{b_A (n_A + 2)^2} - \frac{x_a^2}{2}
\end{aligned} \tag{6.15}$$

$$\begin{aligned}
\Pi_A^d &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} \\
&= \frac{(a_A + n_A (c_A - ((1 - \beta_E) x_a + \beta_E \sum_{i=1}^{n_A} x_i + \beta_E x_A)))^2}{b_A (n_A + 2)^2} + \dots \\
&\quad - \frac{((n_A + 1) (c_A - (x_A + \varphi\beta_I x_B + \beta_E \sum_{i=1}^{n_A} x_i)))^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2}
\end{aligned} \tag{6.16}$$

6.2 Proof of equations (4.11-14)

The FOC in order to calculate the optimal knowledge investments of the competitors applies.

$$\begin{aligned}
\frac{\partial \Pi_a^d}{\partial x_a} &= 2(2 - 2\beta_E + \beta_E n_A) \left(a_A + c_A - x_A - \varphi\beta_I x_B - \beta_E \sum_{i=1}^{n_A} x_i \right) + \dots \\
&\quad - 4(2 - 2\beta_E + \beta_E n_A) \left(c_A - (1 - \beta_E) x_a - \beta_E \sum_{i=1}^{n_A} x_i - \beta_E x_A \right) + \dots \\
&\quad - x_a b_A (n_A + 2)^2 \\
0 &= 2(2 - 2\beta_E + \beta_E n_A) \left(a_A + c_A - x_A - \varphi\beta_I x_B - \beta_E \sum_{i=1}^{n_A} x_i \right) + \dots \\
&\quad - 4(2 - 2\beta_E + \beta_E n_A) \left(c_A - (1 - \beta_E) x_a - \beta_E \sum_{i=1}^{n_A} x_i - \beta_E x_A \right) + \dots \\
&\quad - x_a b_A (n_A + 2)^2
\end{aligned} \tag{6.17}$$

if and only if $FOC = 0$.

$$\begin{aligned}
0 &= 2(2 - 2\beta_E + \beta_E n_A) ((a_A - c_A) - \varphi\beta_I x_B) + \dots \\
&+ 2(2 - 2\beta_E + \beta_E n_A) (2 - 2\beta_E + \beta_E n_A) x_a + \dots \\
&+ 2(2 - 2\beta_E + \beta_E n_A) (2\gamma_A \beta_E - 1) x_A - x_a b_A (n_A + 2)^2
\end{aligned}$$

The optimal knowledge investment policy of the competitors in market A looks as follows:

$$x_a^* = z_A (d_A - r_A x_A - \varphi\beta_I x_B) \quad (6.18)$$

where

$$z_A = \frac{2(2 - 2\beta_E + \beta_E n_A)}{(b_A (n_A + 2)^2 - 2(2 - 2\beta_E + \beta_E n_A)^2)} \quad (6.19)$$

$$d_A = \frac{(a_A - c_A)}{z_A} \quad (6.20)$$

$$r_A = \frac{(2\beta_E + 1)}{z_A} \quad (6.21)$$

The same procedure applies to subsidiary A.

$$\begin{aligned}
\frac{\partial \Pi_A^d}{\partial x_A} &= 2((n_A + 1) - n_A \beta_E) \left(a_A + n_A \left(c_A - (1 - \beta_E) x_a - \beta_E \sum_{i=1}^{n_A} x_i - \beta_E x_A \right) \right) \\
&- 2((n_A + 1) - n_A \beta_E) (n_A + 1) \left(c_A - x_A - \varphi\beta_I x_B - \beta_E \sum_{i=1}^{n_A} x_i \right) + \dots \\
&- x_a b_A (n_A + 2)^2
\end{aligned} \quad (6.22)$$

if and only if $FOC = 0$.

$$\begin{aligned}
x_A &= \frac{2((n_A + 1) - n_A\beta_E)}{b_A(n_A + 2)^2} (a_A - c_A) + \dots \\
&+ \frac{2((n_A + 1) - n_A\beta_E)}{b_A(n_A + 2)^2} (2n_A\beta_E - n_A) x_a + \dots \\
&+ \frac{2((n_A + 1) - n_A\beta_E)}{b_A(n_A + 2)^2} ((1 - n_A\beta_E + n_A) x_A + (1 + n_A) \varphi\beta_I x_B)
\end{aligned}$$

The optimal knowledge investment policy of subsidiary A looks as follows:

$$x_A^* = w_A (g_A + t_A x_a + s_A x_B) \quad (6.23)$$

where

$$w_A = \frac{2((n_A + 1) - n_A\beta_E)}{\left(b_A(n_A + 2)^2 - 2((n_A + 1) - n_A\beta_E)(1 - n_A\beta_E + n_A)\right)} \quad (6.24)$$

$$g_A = \frac{(a_A - c_A)}{w_A} \quad (6.25)$$

$$t_A = \frac{(n_A(\beta_E((1 - n_A)) - 1))}{w_A} \quad (6.26)$$

$$s_A = \frac{(1 + n_A)\varphi\beta_I}{w_A} \quad (6.27)$$

Solving for the optimal knowledge investments we obtain the following equations.

We simplify the factors $\frac{1}{(1+r_A t_A w_A z_A)(1+r_B t_B w_B z_B) - w_A w_B (s_B - t_B z_B \varphi\beta_I)((s_A - t_A z_A \varphi\beta_I))}$ since they are the same for both markets A and B.

$$\begin{aligned}
x_a^* &= z_A (-w_B (g_B + d_B t_B z_B) (r_A s_A w_A + \varphi\beta_I)) + \dots \\
&+ z_A r_A (1 + r_B t_B w_B z_B) (d_A - g_A w_A) + z_A w_B (\varphi\beta_I - s_A w_A) (s_B - t_B z_B \varphi\beta_I)
\end{aligned} \quad (6.28)$$

$$\begin{aligned}
x_A^* &= w_A ((1 + r_B t_B w_B z_B) (g_A + d_A t_A z_A)) + \dots & (6.29) \\
&\quad + w_A w_B (s_A - t_A z_A \varphi \beta_I) (d_B t_B z_B + g_B)
\end{aligned}$$

$$\begin{aligned}
x_b^* &= z_B (-w_A (g_A + d_A t_A z_A) (r_B s_B w_B + \varphi \beta_I)) + \dots & (6.30) \\
&\quad z_B r_B (1 + r_A t_A w_A z_A) (d_B - g_B w_B) + z_B w_A (\varphi \beta_I - s_B w_B) (s_A - t_A z_A \varphi \beta_I)
\end{aligned}$$

$$\begin{aligned}
x_B^* &= w_B ((1 + r_A t_A w_A z_A) (g_B + d_B t_B z_B)) + \dots & (6.31) \\
&\quad + w_B w_A (s_B - t_B z_B \varphi \beta_I) (d_A t_A z_A + g_A)
\end{aligned}$$

Chapter 7

Appendix 2 - Scenario 2

The centralized knowledge investment policy is modeled within scenario 2. The HQ is the relevant actor within the knowledge investment process and both subsidiaries A and B are just receiving internal knowledge spillovers from the headquarter and are no more actively participating to this process. The effective knowledge investments under centralized knowledge investment policy depend on the knowledge investment of the headquarter x_H as well as on the knowledge investment activity of the competitors in the relevant market. In fact, both subsidiaries are not involved in the knowledge production processes under centralization.

$$X_A^c = \varphi\beta_I x_H + \beta_E \sum_{a=1}^{n_A} x_a \quad (7.1)$$

$$X_B^c = \varphi\beta_I x_H + \beta_E \sum_{b=1}^{n_B} x_b \quad (7.2)$$

$$X_i^c = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a = (1 - \beta_E) x_i + \beta_E \sum_{a=1}^{n_A} x_a \quad (7.3)$$

$$X_j^c = x_j + \beta_E \sum_{b=1, b \neq j}^{n_B} x_b = (1 - \beta_E) x_j + \beta_E \sum_{b=1}^{n_B} x_b \quad (7.4)$$

The cost functions may be derived according to the assumption that knowledge investments aim at reducing costs.

$$C_A^c(q_A, X_A) = (c_A - X_A^c)q_A = (c_A - \varphi\beta_I x_H - \beta_E \sum_{a=1}^{n_A} x_a)q_A \quad (7.5)$$

$$C_B^c(q_B, X_B) = (c_B - X_B^c)q_B = (c_B - \varphi\beta_I x_H - \beta_E \sum_{b=1}^{n_B} x_b)q_B \quad (7.6)$$

$$C_i^c(q_i, X_i) = (c_i - X_i^c)q_i = \left(c_i - \left((1 - \beta_E)x_i + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_i \quad (7.7)$$

$$C_j^c(q_j, X_j) = (c_j - X_j^c)q_j = \left(c_j - \left((1 - \beta_E)x_j + \beta_E \sum_{b=1}^{n_B} x_b \right) \right) q_j \quad (7.8)$$

The profit maximization functions of the subsidiaries A and B are displayed in the following equations:

$$\max_{q_A} \pi_A^c = \max \left(a_A - b_A \left(\sum_{a=1, a \neq i}^{n_A} q_a + q_A \right) - (c_A - X_A^c) \right) q_A - \frac{x_H^2}{2} \quad (7.9)$$

$$\max_{q_B} \pi_B^c = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_B - X_B^c) \right) q_B - \frac{x_H^2}{2} \quad (7.10)$$

The other companies in market A and B display the following profit maximization functions:

$$\max_{q_i} \pi_i^c = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^c) \right) q_i - \zeta_A \frac{x_i^2}{2} \quad (7.11)$$

$$\max_{q_j} \pi_j^c = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_j - X_j^c) \right) q_j - \zeta_B \frac{x_j^2}{2} \quad (7.12)$$

7.1 Proof of equations (4.31) and (4.32)

The FOC can be derived in order to compute the optimal output respectively of subsidiary A and B and of all the competitors in the two markets A and B.

$$\frac{\partial \pi_A^c}{\partial q_A} = a_A - c_A + X_A^c - 2b_A q_A - b_A \sum_{a=1, a \neq j}^{n_A} q_a \quad (7.13)$$

$$= a_A - c_A + X_A^c - 2b_A q_A - b_A n_A q_i = 0$$

$$q_A^* = \frac{1}{2b_A} (a_A - c_A + X_A^c - b_A n_A q_i)$$

$$\frac{\partial \pi_i^c}{\partial q_i} = a_A - c_i + X_i^c - b_A q_A - b_A (n_A + 1) q_i = 0 \quad (7.14)$$

$$q_i^* = \frac{1}{b_A (n_A + 1)} (a_A - c_i + X_i^c - b_A q_A)$$

$$\frac{\partial \pi_B^c}{\partial q_B} = a_B - c_B + X_B^c - 2b_B q_B - b_B n_B q_j = 0 \quad (7.15)$$

$$q_B^* = \frac{1}{2b_B} (a_B - c_B + X_B^c - b_B n_B q_j)$$

$$\frac{\partial \pi_j^c}{\partial q_j} = a_B - c_j + X_j^c - b_B q_B - b_B (n_B + 1) q_j = 0 \quad (7.16)$$

$$q_j^* = \frac{1}{b_B (n_B + 1)} (a_B - c_j + X_j^c - b_B q_B)$$

Accordingly, the optimal output in market A and B can be computed:

$$q_a^* = \frac{1}{b_A (n_A + 2)} (a_A - 2C_a + C_A) \quad (7.17)$$

$$q_A^* = \frac{1}{b_A (n_A + 2)} (a_A - (n_A + 1) C_A + n_A C_a) \quad (7.18)$$

$$q_b^* = \frac{1}{b_B (n_B + 2)} (a_B - 2C_b + C_B) \quad (7.19)$$

$$q_B^* = \frac{1}{b_B (n_B + 2)} (a_B - (n_B + 1) C_B + n_B C_b) \quad (7.20)$$

7.2 Proof of equations (4.34-37)

Starting from the profit functions, the optimal knowledge investments of the MNC as a whole can be derived in order to compare the investments under centralized knowledge production policy with those under decentralized knowledge investment policy.

$$\begin{aligned}\Pi_a^c &= \frac{(a_A + C_A - 2C_a)^2}{b_A (n_A + 2)^2} - \frac{x_a^2}{2} \\ \Pi_a^c &= \frac{(a_A + (c_A - \varphi\beta_I x_H - \beta_E \sum_{i=1}^{n_A} x_i))^2}{b_A (n_A + 2)^2} + \dots \\ &\quad - \frac{(2(c_A - ((1 - \beta_E)x_a + \beta_E \sum_{i=1}^{n_A} x_i)))^2}{b_A (n_A + 2)^2} - \frac{x_a^2}{2}\end{aligned}\tag{7.21}$$

$$\begin{aligned}\Pi_A^c &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_H^2}{2} \\ \Pi_A^c &= \frac{(a_A + n_A (c_A - ((1 - \beta_E)x_a + \beta_E \sum_{i=1}^{n_A} x_i)))^2}{b_A (n_A + 2)^2} + \dots \\ &\quad - \frac{((n_A + 1)(c_A - \varphi\beta_I x_H - \beta_E \sum_{i=1}^{n_A} x_i))^2}{b_A (n_A + 2)^2} - \frac{x_H^2}{2}\end{aligned}\tag{7.22}$$

$$\begin{aligned}\Pi_b^c &= \frac{(a_B + C_B - 2C_b)^2}{b_B (n_B + 2)^2} - \frac{x_b^2}{2} \\ &= \frac{(a_B + (c_B - (\varphi\beta_I x_H + \beta_E \sum_{j=1}^{n_B} x_j)))^2}{b_B (n_B + 2)^2} + \dots \\ &\quad - \frac{(2(c_B - ((1 - \beta_E)x_b + \beta_E \sum_{j=1}^{n_B} x_j)))^2}{b_B (n_B + 2)^2} - \frac{x_b^2}{2}\end{aligned}\tag{7.23}$$

$$\begin{aligned}\Pi_B^c &= \frac{(a_B + n_B C_b - (n_B + 1) C_B)^2}{b_B (n_B + 2)^2} - \frac{x_H^2}{2} \\ &= \frac{(a_B + n_B (c_B - ((1 - \beta_E)x_b + \beta_E \sum_{b=1}^{n_B} x_b)))^2}{b_B (n_B + 2)^2} + \dots \\ &\quad - \frac{((n_B + 1)(c_B - \varphi\beta_I x_H - \gamma_B \beta_E \sum_{j=1}^{n_B} x_j))^2}{b_B (n_B + 2)^2} - \frac{x_H^2}{2}\end{aligned}\tag{7.24}$$

Solving for the optimal knowledge quantity of the HQ under knowledge production centralization:

$$\begin{aligned}
\Pi_H^c &= \Pi_A^c + \Pi_B^c & (7.25) \\
\Pi_H^c &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_H^2}{2} + \dots \\
&+ \frac{(a_B + n_B C_b - (n_B + 1) C_B)^2}{b_B (n_B + 2)^2} - \frac{x_H^2}{2} \\
\Pi_H^c &= \frac{(a_A + n_A (c_A - ((1 - \beta_E) x_a + \beta_E \sum_{i=1}^{n_A} x_i)))^2}{b_A (n_A + 2)^2} + \dots \\
&- \frac{((n_A + 1) (c_A - \varphi \beta_I x_H - \beta_E \sum_{i=1}^{n_A} x_i))^2}{b_A (n_A + 2)^2} + \dots \\
&+ \frac{(a_B + n_B (c_B - ((1 - \beta_E) x_b + \beta_E \sum_{b=1}^{n_B} x_b)))^2}{b_B (n_B + 2)^2} + \dots \\
&- \frac{((n_B + 1) (c_B - \varphi \beta_I x_H - \beta_E \sum_{j=1}^{n_B} x_j))^2}{b_B (n_B + 2)^2} - x_H^2 b_A (n_A + 2)^2 b_B (n_B + 2)^2 \\
\frac{\partial \Pi_H^c}{\partial x_H} &= \frac{2}{z_H} \left(a_A + n_A \left(c_A - \left((1 - \beta_E) x_a + \beta_E \sum_{i=1}^{n_A} x_i \right) \right) \right) + \dots \\
&- \frac{2}{z_H} (n_A + 1) \left(c_A - \varphi \beta_I x_H - \beta_E \sum_{i=1}^{n_A} x_i \right) - \frac{2}{z_H} \left(b_A (n_A + 2)^2 b_B (n_B + 2)^2 \right) 2x_H + \dots \\
&+ \frac{4}{z_H} \left(a_B + n_B \left(c_B - \left((1 - \beta_E) x_b + \beta_E \sum_{b=1}^{n_B} x_b \right) \right) \right) + \dots \\
&- \frac{4}{z_H} \left((n_B + 1) \left(c_B - \varphi \beta_I x_H - \beta_E \sum_{j=1}^{n_B} x_j \right) \right) \\
0 &= \frac{2}{z_H} (a_A + c_A n_A - n_A x_a + n_A \beta_E x_a - n_A \beta_E n_A x_a - n_A c_A) + \dots \\
&+ \frac{2}{z_H} (n_A \varphi \beta_I x_H + n_A \beta_E n_A x_a - c_A + \varphi \beta_I x_H + \beta_E n_A x_a) + \dots \\
&- \frac{2}{z_H} \left(b_A (n_A + 2)^2 b_B (n_B + 2)^2 \right) 2x_H + \dots \\
&+ \frac{4}{z_H} (a_B + n_B c_B - n_B x_b + n_B \beta_E x_b - n_B \beta_E n_B x_b - n_B c_B) + \dots \\
&+ \frac{4}{z_H} (n_B \varphi \beta_I x_H + n_B \beta_E n_B x_b - c_B + \varphi \beta_I x_H + \beta_E n_B x_b) + \dots \\
&+ \frac{4}{z_H} \left(b_A (n_A + 2)^2 b_B (n_B + 2)^2 \right) - \varphi \beta_I (n_A + 1) - \varphi \beta_I (n_B + 1) x_H
\end{aligned}$$

Hence, the optimal knowledge investment production of the headquarter can be derived

$$x_H^* = z_H (d_A - t_A x_a) + 2 (d_B - t_B x_b) \quad (7.26)$$

where

$$z_H = \frac{1}{\left(2 \left(b_A (n_A + 2)^2 b_B (n_B + 2)^2\right) - \varphi \beta_I ((n_A + 1) + (n_B + 1))\right)} \quad (7.27)$$

$$d_A = \frac{(a_A - c_A)}{z_H} \quad (7.28)$$

$$t_A = \frac{(n_A (1 + \beta_E (n_A - 1) + \beta_E (n_A + 1)))}{z_H} \quad (7.29)$$

$$d_B = \frac{(a_B - c_B)}{z_H} \quad (7.30)$$

$$t_B = \frac{(n_B (1 + \beta_E (n_B - 1) + \beta_E (n_B + 1)))}{z_H} \quad (7.31)$$

Optimal knowledge investment of competitors in market A

$$\begin{aligned} \frac{\partial \Pi_a^c}{\partial x_a} &= 2(2 - 2\beta_E + \beta_E n_A) \left(a_A + \left(c_A - \left(\varphi \beta_I x_H + \beta_E \sum_{i=1}^{n_A} x_i \right) \right) \right) + \dots \quad (7.32) \\ &\quad - 2(2 - 2\beta_E + \beta_E n_A) \left(2 \left(c_A - \left(x_a - \beta_E x_a + \beta_E \sum_{i=1}^{n_A} x_i \right) \right) \right) + \dots \\ &\quad - x_a b_A (n_A + 2)^2 \end{aligned}$$

if and only if

$$\begin{aligned} x_a &= \frac{2(2 - 2\beta_E + \beta_E n_A)}{b_A (n_A + 2)^2} (a_A - c_A) + \dots \\ &\quad - 2(2 - 2\beta_E + \beta_E n_A) \varphi \beta_I x_H + \dots \\ &\quad + 2(2 - 2\beta_E + \beta_E n_A) (2 - 2\beta_E + \beta_E n_A) x_a \\ x_a^* &= z_A ((a_A - c_A) - \varphi \beta_I x_H) \end{aligned}$$

where

$$z_A = \frac{2(2 - 2\beta_E + \beta_E n_A)}{(b_A(n_A + 2)^2 - 2(2 - 2\beta_E + \beta_E n_A)^2)} \quad (7.33)$$

Optimal knowledge investment of competitors in market B

$$\begin{aligned} \frac{\partial \Pi_b^c}{\partial x_b} &= 2(2 - 2\beta_E + \beta_E n_B) \left(a_B + \left(c_B - \left(\varphi \beta_I x_H + \beta_E \sum_{j=1}^{n_B} x_j \right) \right) \right) + \dots \quad (7.34) \\ &\quad - 4(2 - 2\beta_E + \beta_E n_B) \left(c_B - \left(x_b - \beta_E x_b + \beta_E \sum_{j=1}^{n_B} x_j \right) \right) + \dots \\ &\quad - 2x_b b_B (n_B + 2)^2 \end{aligned}$$

$$x_b^* = z_B ((a_B - c_B) - \varphi \beta_I x_H) \quad (7.35)$$

where

$$z_B = \frac{2(2 - 2\beta_E + \beta_E n_B)}{(b_B(n_B + 2)^2 - 2(2 - 2\beta_E + \beta_E n_B)^2)} \quad (7.36)$$

Therefore, the optimal knowledge investment productions policies may be subsumed as follows:

$$x_a^* = z_A ((a_A - c_A) - \varphi \beta_I x_H) \quad (7.37)$$

$$x_b^* = z_B ((a_B - c_B) - \varphi \beta_I x_H) \quad (7.38)$$

$$x_H^* = z_H (d_A - t_A x_a) + 2(d_B - t_B x_b) \quad (7.39)$$

Conjecture 17 *No competitors are present in both market A and B, such that $n_A = n_B = 0$. This allows for a complete focus on the definition of the MNC.*

$$x_a^* = z_A ((a_A - c_A) - \varphi\beta_I x_H) \quad (7.40)$$

$$x_b^* = z_B ((a_B - c_B) - \varphi\beta_I x_H) \quad (7.41)$$

$$x_H^* = z_H (d_A - t_A x_a) + 2(d_B - t_B x_b) \quad (7.42)$$

$$x_H^* = z_H (d_A - t_A z_A ((a_A - c_A) - \varphi\beta_I x_H)) + \dots \quad (7.43)$$

$$+ 2z_H (d_B - t_B z_B ((a_B - c_B) - \varphi\beta_I x_H)) \quad (7.44)$$

$$x_H^* = z_H d_A - z_H t_A z_A (a_A - c_A) + z_H t_A z_A \varphi\beta_I x_H + \dots \quad (7.45)$$

$$+ 2d_B - 2t_B z_B (a_B - c_B) + 2t_B z_B \varphi\beta_I x_H \quad (7.46)$$

$$x_H = \frac{1}{(1 - z_H t_A z_A \varphi\beta_I - 2t_B z_B \varphi\beta_I)} z_H d_A - z_H t_A z_A (a_A - c_A) + 2d_B + \dots \quad (7.47)$$

$$- 2t_B z_B (a_B - c_B)$$

$$x_H = z_H d_A + 2d_B \quad (7.48)$$

$$x_H = \left((a_A - c_A) + (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right) \quad (7.49)$$

where $z_H = \frac{1}{2(4b_A 4b_B - 2\varphi\beta_I)}$ and $z_A = \frac{2(2-2\beta_E)}{4\zeta_A b_A - 2(2-2\beta_E)^2}$

Inserting x_H as the optimal knowledge investment quantity within the profit functions we can obtain the profit of the MNC as a whole.

$$\Pi_A^c = \frac{(a_A - c_A + \varphi\beta_I x_H)^2}{4b_A} - \frac{x_H^2}{2} \quad (7.50)$$

$$\Pi_B^c = \frac{(a_B - c_B + \varphi\beta_I x_H)^2}{4b_B} - \frac{x_H^2}{2} \quad (7.51)$$

$$\Pi_H^c = \frac{((a_A - c_A) + \varphi\beta_I x_H)^2}{4b_A} + \frac{((a_B - c_B) + \varphi\beta_I x_H)^2}{4b_B} - x_H^2 \quad (7.52)$$

$$\begin{aligned} \Pi_H^c &= \frac{\left((a_A - c_A) + \varphi\beta_I \left((a_A - c_A) + (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right) \right)^2}{4b_A} + \dots \quad (7.53) \\ &+ \frac{\left((a_B - c_B) + \varphi\beta_I \left((a_A - c_A) + (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right) \right)^2}{4b_B} - x_H^2 \\ &= \frac{4b_B \left((a_A - c_A) (1 + \varphi\beta_I) + \varphi\beta_I (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right)^2}{4b_A 4b_B} + \dots \\ &+ \frac{4b_A \left((a_B - c_B) \left(1 + \varphi\beta_I \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right) + \varphi\beta_I (a_A - c_A) \right)^2}{4b_A 4b_B} + \dots \\ &- \left((a_A - c_A) + (a_B - c_B) \left(\frac{1}{(4b_A 4b_B - 2\varphi\beta_I)} \right) \right)^2 \end{aligned}$$

Conjecture 18 *Assuming furthermore that no competitors can be found in the markets of relevance A and B, such that $\beta_I = 0$ we obtain the profit of both the headquarter and subsidiary A to be compared to those under decentralized knowledge investment policy.*

$$\Pi_H^c = \frac{4b_B (a_A - c_A)^2 + 4b_A (a_B - c_B)^2}{4b_A 4b_B} - \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2 \quad (7.54)$$

$$\Pi_A^c = \frac{(a_A - c_A)^2}{4b_A} - 2 \left(\frac{4b_A 4b_B (a_A - c_A) + (a_B - c_B)}{4b_A 4b_B} \right)^2 \quad (7.55)$$

Chapter 8

Appendix 3 - Scenario 3

The effective knowledge investments under HQ intervention within decentralization depend on the knowledge portion $(x_H - x_A)$ carried out centrally by the HQ as well as on the knowledge portion x_A delegated to subsidiary A. Therefore, the involved actors are the headquarter and subsidiary A as a centre of excellence. Subsidiary B that is not actively involved in the knowledge production process and is enjoying internal knowledge spillovers thanks to being part of the multinational company.

$$X_H = (1 - \alpha)(x_H - x_A) + \varphi\beta_I\alpha x_A \quad (8.1)$$

$$X_A = \alpha x_A + \varphi\beta_I(1 - \alpha)(x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a \quad (8.2)$$

$$X_B = \varphi\beta_I\alpha x_A + \varphi\beta_I(1 - \alpha)(x_H - x_A) + \beta_E \sum_{b=1}^{n_B} x_b \quad (8.3)$$

$$X_i = x_i + \beta_E \sum_{a=1, a \neq i}^{n_A} x_a + \beta_E \alpha x_A = (1 - \beta_E)x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \alpha x_A \quad (8.4)$$

The cost functions mirrors that knowledg investment aims at reducing costs. Moreover, it can be seen that subsidiary B is not active in knowledge production since it is only receiving internal knowledge spillovers from the headquarter und not sending external spillovers to the external environment.

$$C_A^{di}(q_A, X_A^{di}) = (c_A - X_A) q_A \quad (8.5)$$

$$= \left(c_A - \left(\alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a \right) \right) q_A$$

$$C_B^{di}(q_B, X_B^{di}) = (c_B - X_B) q_B \quad (8.6)$$

$$= \left(c_B - \left(\varphi \beta_I \alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{b=1}^{n_B} x_b \right) \right) q_B$$

$$C_i^{di}(q_i, X_i^{di}) = (c_i - X_i) q_i \quad (8.7)$$

$$= \left(c_i - \left((1 - \beta_E) x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \alpha x_A \right) \right) q_i$$

$$C_j^{di}(q_j, X_j^{di}) = (c_j - X_j) q_j = \left(c_j - \left((1 - \beta_E) x_j + \beta_E \sum_{b=1}^{n_B} x_b \right) \right) q_j \quad (8.8)$$

Moreover, the headquarter has a own cost function since it is actively participating to the knowledge investment:

$$C_H^{di}(q_H, X_H^{di}) = (c_H - X_H) q_H = (c_H - ((1 - \alpha) (x_H - x_A) + \varphi \beta_I \alpha x_A)) q_H \quad (8.9)$$

The profit maximization fuctions of the subsidiary A (centre of excellence) and B are displayed in the following equations:

$$\max_{q_A} \pi_A^{di} = \max \left(a_A - b_A \left(\sum_{a=1, a \neq i}^{n_A} q_a + q_A \right) - (c_A - X_A^{di}) \right) q_A - \frac{x_A^2}{2} \quad (8.10)$$

$$\max_{q_B} \pi_B^{di} = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_B - X_B^{di}) \right) q_B \quad (8.11)$$

The profit maximization function of subsidiary B does not display quadratic knowledge

investments costs, since subsidiary B is not investing in knowledge at all.

The other companies in market A and B display the following profit maximization functions:

$$\max_{q_i} \pi_i^{di} = \max \left(a_A - b_A \left(\sum_{a=1}^{n_A} q_a + q_A \right) - (c_i - X_i^{di}) \right) q_i - \zeta_A \frac{x_i^2}{2} \quad (8.12)$$

$$\max_{q_j} \pi_j^{dj} = \max \left(a_B - b_B \left(\sum_{b=1}^{n_B} q_b + q_B \right) - (c_j - X_j^{dj}) \right) q_j - \zeta_B \frac{x_j^2}{2} \quad (8.13)$$

8.1 Proof of equations (4.55) and (4.56)

The FOC can be derived in order to compute the optimal output respectively of subsidiary A and B and of all the competitors in the two markets A and B.

$$\frac{\partial \pi_A^{di}}{\partial q_A} = a_A - c_A + X_A^{di} - 2b_A q_A - b_A \sum_{a=1, a \neq j}^{n_A} q_a \quad (8.14)$$

$$= a_A - c_A + X_A^{di} - 2b_A q_A - b_A n_A q_i = 0$$

$$q_A^{di*} = \frac{1}{2b_A} (a_A - c_A + X_A^c - b_A n_A q_i)$$

$$\frac{\partial \pi_i^{di}}{\partial q_i} = a_A - c_i + X_i^{di} - b_A q_A - b_A (n_A + 1) q_i = 0 \quad (8.15)$$

$$q_i^{di*} = \frac{1}{b_A (n_A + 1)} (a_A - c_i + X_i^c - b_A q_A)$$

The optimal quantities in market A are derived accordingly.

$$q_A^{di*} = \frac{1}{b_A (n_A + 2)} (a_A - (n_A + 1) C_A + n_A C_a) \quad (8.16)$$

$$q_a^{di*} = \frac{1}{b_A (n_A + 2)} (a_A - 2C_a + C_A) \quad (8.17)$$

The profit functions for the centre of excellence and all the other subsidiaries in market

A are the following:

$$\Pi_a^{di} = \frac{(a_A + C_A - 2C_a)^2}{b_A (n_A + 2)^2} - \zeta_A \frac{x_a^2}{2} \quad (8.18)$$

$$\begin{aligned} \Pi_a^{di} &= \frac{(a_A + (c_A - (\alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a)))^2}{b_A (n_A + 2)^2} + \dots \\ &\quad - \frac{(2(c_A - ((1 - \beta_E) x_a + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \alpha x_A)))^2}{b_A (n_A + 2)^2} - \zeta_A \frac{x_a^2}{2} \\ \Pi_A^{di} &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} \end{aligned} \quad (8.19)$$

$$\begin{aligned} \Pi_A^{di} &= \frac{(a_A + n_A (c_A - ((1 - \beta_E) x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \alpha x_A)))^2}{b_A (n_A + 2)^2} + \dots \\ &\quad - \frac{((n_A + 1) ((c_A - (\alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a))))^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} \end{aligned}$$

8.2 Proof of equation (4.59)

Deriving the FOC for optimal knowledge quantities of the competitors in market A:

$$\begin{aligned} \frac{\partial \Pi_a^{di}}{\partial x_a} &= 2(2 - 2\beta_E + \beta_E n_A) ((a_A - c_A) - \varphi \beta_I (1 - \alpha) x_H) + \dots \\ &\quad + 2(2 - 2\beta_E + \beta_E n_A) (2\beta_E \alpha ((1 - \alpha) \varphi \beta_I - \alpha) x_A) + \dots \\ &\quad + 2(2 - 2\beta_E + \beta_E n_A) ((2 - 2\beta_E + \beta_E n_A) x_a) + \dots \\ &\quad - \zeta_A x_a b_A (n_A + 2)^2 \end{aligned} \quad (8.20)$$

if and only if FOC = 0.

$$\begin{aligned}
0 &= 2(2 - 2\beta_E + \beta_E n_A) ((a_A - c_A) - \varphi\beta_I(1 - \alpha)x_H) + \dots & (8.21) \\
&+ 2(2 - 2\beta_E + \beta_E n_A) (2\beta_E\alpha((1 - \alpha)\varphi\beta_I - \alpha)x_A) + \dots \\
&+ 2(2 - 2\beta_E + \beta_E n_A) ((2 - 2\beta_E + \beta_E n_A)x_a) + \dots \\
&- \zeta_A x_a b_A (n_A + 2)^2
\end{aligned}$$

The optimal knowledge investment policy of the competitors in market A looks as follows:

$$x_a^* = z_a \left(d_a + r_a x_A - \frac{\varphi\beta_I(1 - \alpha)}{z_a} x_H \right) \quad (8.22)$$

where

$$z_a = \frac{2(2 - 2\beta_E + \beta_E n_A)}{\left(\zeta_A b_A (n_A + 2)^2 - 2(2 - 2\beta_E + \beta_E n_A) \right)} \quad (8.23)$$

$$d_a = \frac{(a_A - c_A)}{z_a} \quad (8.24)$$

$$r_a = \frac{-2\beta_E\alpha^2}{z_a} \quad (8.25)$$

8.3 Proof of equations (4.61-4.62)

The same procedure for deriving the FOC applies to the centre of excellence:

$$\begin{aligned}
\frac{\partial \Pi_A^{di}}{\partial x_A} &= 2((n_A + 1)\alpha + (n_A\varphi\beta_I + \varphi\beta_I)(\alpha - 1) - n_A\beta_E\alpha)(a_A - c_A) + \dots & (8.26) \\
&+ 2((n_A + 1)\alpha + (n_A\varphi\beta_I + \varphi\beta_I)(\alpha - 1) - n_A\beta_E\alpha)^2 x_A + \dots \\
&+ 2((n_A + 1)\alpha + (n_A\varphi\beta_I + \varphi\beta_I)(\alpha - 1) - n_A\beta_E\alpha)((n_A\varphi\beta_I + \varphi\beta_I)(1 - \alpha)x_H) + \dots \\
&+ ((\beta_E n_A(1 + n_A) + n_A\beta_E(1 - n_A) - n_A)x_a) + \dots \\
&- x_A b_A (n_A + 2)^2
\end{aligned}$$

The optimal knowledge investments of the centre of excellence A are the following:

$$x_A^{di*} = z_A (d_A + r_A x_a + (n_A\varphi\beta_I + \varphi\beta_I)(1 - \alpha)x_H) \quad (8.27)$$

where

$$z_A = \frac{2((n_A + 1)\alpha + (n_A\varphi\beta_I + \varphi\beta_I)(\alpha - 1) - n_A\beta_E\alpha)}{\left(b_A(n_A + 2)^2 - 2((n_A + 1)\alpha + (n_A\varphi\beta_I + \varphi\beta_I)(\alpha - 1) - n_A\beta_E\alpha)\right)} \quad (8.28)$$

$$d_A = \frac{(a_A - c_A)}{z_A} \quad (8.29)$$

$$r_A = \frac{(\beta_E n_A(1 + n_A) + \beta_E n_A(1 - n_A) - n_A)}{z_A} \quad (8.30)$$

Deriving for the optimal knowledge investment of the headquarter:

$$\begin{aligned}
\Pi_H &= \Pi_A + \Pi_B & (8.31) \\
\Pi_H &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} + \dots \\
&\quad + \frac{(a_B + n_B C_b - (n_B + 1) C_B)^2}{b_B (n_B + 2)^2} \\
\Pi_H &= \frac{(a_A + n_A (c_A - ((1 - \beta_E) x_i + \beta_E \sum_{a=1}^{n_A} x_a + \beta_E \alpha x_A)))^2}{b_A (n_A + 2)^2} + \dots \\
&\quad - \frac{((n_A + 1) (c_A - (\alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{a=1}^{n_A} x_a)))^2}{b_A (n_A + 2)^2} + \dots \\
&\quad + \frac{(a_B + n_B (c_B - ((1 - \beta_E) x_b + \beta_E \sum_{b=1}^{n_B} x_b)))^2}{b_B (n_B + 2)^2} + \dots \\
&\quad - \frac{((n_B + 1) (c_B - (\varphi \beta_I \alpha x_A + \varphi \beta_I (1 - \alpha) (x_H - x_A) + \beta_E \sum_{b=1}^{n_B} x_b)))^2}{b_B (n_B + 2)^2} + \dots \\
&\quad - \frac{x_A^2}{2} \\
\frac{\partial \Pi_H}{\partial x_H} &= \frac{2}{z_H} (a_A + n_A (c_A - x_a + \beta_E x_a - \beta_E n_A x_a - \beta_E \alpha x_A)) + \dots \\
&\quad - \frac{2}{z_H} (n_A + 1) (c_A - \alpha x_A - \varphi \beta_I x_H + \varphi \beta_I \alpha x_H + \varphi \beta_I x_A - \varphi \beta_I \alpha x_A - \beta_E n_A x_a) + \dots \\
&\quad - \frac{4}{z_H} x_A^2 (b_A (n_A + 2)^2 b_B (n_B + 2)^2) + \dots \\
&\quad + \frac{2}{z_H} (a_B + n_B (c_B - x_b + \beta_E x_b - \beta_E n_B x_b)) + \dots \\
&\quad - \frac{2}{z_H} ((n_B + 1) (c_B - \varphi \beta_I \alpha x_A + \varphi \beta_I \alpha x_H + \varphi \beta_I x_A - \varphi \beta_I x_H + \varphi \beta_I x_A - \beta_E n_B x_b)) \\
x_H^* &= z_H ((a_A - c_A) + (n_A \beta_E - n_A - \beta_E n_A^2 + \gamma_A \beta_E n_A^2 + \gamma_A \beta_E n_A) x_a) + \dots \\
&\quad + (\alpha - n_A \gamma_A \beta_E \alpha - 2\varphi \beta_I + \varphi \beta_I \alpha + n_A \alpha - n_A \varphi \beta_I + n_A \varphi \beta_I \alpha - n_B \varphi \beta_I) x_A + \dots \\
&\quad + (a_B - c_B) + (2\beta_E n_B - n_B) x_b
\end{aligned}$$

where

$$z_H = \frac{(-2\varphi\beta_I + 2\varphi\beta_I\alpha)}{\left(b_A(n_A + 2)^2 b_B(n_B + 2)^2\right) - (2\varphi\beta_I(\alpha - 1))((\alpha - 1)(\varphi\beta_I(2 + n_A + n_B)))} \quad (8.32)$$

$$t_H = (2\beta_E n_A - n_A) \quad (8.33)$$

$$s_H = (\alpha - n_A\beta_E\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha + n_A\alpha - n_A\varphi\beta_I + n_A\varphi\beta_I\alpha - n_B\varphi\beta_I) \quad (8.34)$$

$$g_H = (2\beta_E n_B - n_B) \quad (8.35)$$

such that

$$x_H^* = z_H((a_A - c_A) + t_H x_a + s_H x_A + (a_B - c_B) + g_H x_b) \quad (8.36)$$

Therefore, the optimal knowledge investment production policies may be subsumed as follows:

$$x_a^{di*} = z_a \left(d_a + r_a x_A - \frac{\varphi\beta_I(1 - \alpha)}{z_a} x_H \right) \quad (8.37)$$

$$x_A^{di*} = z_A \left(d_A + r_A x_a + \frac{(n_A\varphi\beta_I + \varphi\beta_I)(1 - \alpha)}{z_A} x_H \right) \quad (8.38)$$

$$x_H^{di*} = z_H((a_A - c_A) + t_H x_a + s_H x_A + (a_B - c_B) + g_H x_b) \quad (8.39)$$

Conjecture 19 *No competitors are present in both market A and B, such that $n_A = n_B = 0$. This allows for a complete focus on the definition of the MNC.*

$$x_a^* = z_a \left(d_a + r_a x_A - \frac{\varphi\beta_I(1-\alpha)}{z_a} x_H \right) \quad (8.40)$$

$$x_A^* = z_A \left(d_A + \frac{\varphi\beta_I(1-\alpha)}{z_A} x_H \right) \quad (8.41)$$

$$x_H^* = z_H \left((a_A - c_A) + (a_B - c_B) + \frac{(\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha)}{z_H} x_A \right) \quad (8.42)$$

$$x_H^* = \frac{1}{(1 - (\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha) \varphi\beta_I (1 - \alpha))} ((a_A - c_A) (1 - (\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha)) + (a_B - c_B)) \quad (8.43)$$

$$x_A^* = 2(a_A - c_A) + (a_B - c_B) \left(\frac{\varphi\beta_I(1-\alpha)}{(1 - (\alpha - 2\varphi\beta_I + \varphi\beta_I\alpha) \varphi\beta_I (1 - \alpha))} \right) \quad (8.44)$$

8.4 Proof of equation (4.82)

After having derived the optimal knowledge quantities of the actors involved within scenario 3, the optimal delegational policy is looked at. The starting point is the profit function of the centre of excellence A. The assumptions underlying the model are the same as elucidated at the beginning of chapter 4, section 4.4.

$$\begin{aligned}
\Pi_A^{di} &= \frac{(a_A + n_A C_a - (n_A + 1) C_A)^2}{b_A (n_A + 2)^2} - \frac{x_A^2}{2} & (8.45) \\
\Pi_A^{di} &= \frac{(a_A - c_A - n_A x_a + n_A \beta_E x_a - \beta_E n_A^2 x_a - n_A \beta_E \alpha x_A)^2}{b_A (n_A + 2)^2} + \dots \\
&+ \frac{(\alpha x_A + \varphi \beta_I x_H - \varphi \beta_I \alpha x_H - \varphi \beta_I x_A + \varphi \beta_I \alpha x_A + \beta_E n_A x_a)^2}{b_A (n_A + 2)^2} + \dots \\
&+ \frac{(n_A \alpha x_A + n_A \varphi \beta_I x_H - n_A \varphi \beta_I \alpha x_H - n_A \varphi \beta_I x_A + n_A \varphi \beta_I \alpha x_A + \beta_E n_A^2 x_a)^2}{b_A (n_A + 2)^2} + \dots \\
&- \frac{x_A^2}{2}
\end{aligned}$$

Once the profit function is known in extended form, we can derive for the optimal α .

$$\begin{aligned}
\frac{\partial \Pi_A^{di}}{\partial \alpha} &= g_\alpha (a_A - c_A) + g_\alpha ((\beta_E n_A + \beta_E n_A^2 (\gamma_A - 1) - n_A) x_a) + \dots \\
&+ g_\alpha ((\alpha (1 + \varphi \beta_I (1 + n_A) + n_A (1 - \beta_E)) - \varphi \beta_I (1 + n_A)) x_A) + \dots \\
&+ 2g_\alpha (((\varphi \beta_I (1 - \alpha)) (1 + n_A)) x_H) + \dots \\
&- \frac{x_A^2}{2} b_A (n_A + 2)^2
\end{aligned}$$

where

$$g_\alpha = 2((\varphi \beta_I (1 + n_A) - n_A (\gamma_A \beta_E - 1)) x_A - (\varphi \beta_I (1 + n_A)) x_H) \quad (8.46)$$

if and only if FOC = 0.

$$\begin{aligned}
0 &= g_\alpha (a_A - c_A) + g_\alpha ((\beta_E n_A (\gamma_A + 1) + \beta_E n_A^2 (\gamma_A - 1) - n_A) x_a) + \dots \\
&\quad + g_\alpha ((\alpha (1 + \varphi \beta_I (1 + n_A) + n_A (1 - \gamma_A \beta_E)) - \varphi \beta_I (1 + n_A)) x_A) + \dots \\
&\quad + g_\alpha (((\varphi \beta_I (1 - \alpha)) (1 + n_A)) x_H) + \dots \\
&\quad - \frac{x_A^2}{2} b_A (n_A + 2)^2
\end{aligned}$$

The optimal α may now be calculated:

$$\alpha^* = z_\alpha ((a_A - c_A) + (\beta_E n_A - \beta_E n_A^2 - n_A) x_a) - \frac{x_A^2}{2} b_A (n_A + 2)^2 \quad (8.47)$$

where

$$z_\alpha = \frac{2((\varphi \beta_I (1 + n_A) - n_A (\beta_E - 1)) x_A - (\varphi \beta_I (1 + n_A)) x_H)}{2((\varphi \beta_I (1 + n_A) - n_A (\beta_E - 1)) x_A - (\varphi \beta_I (1 + n_A)) x_H)} = 1 \quad (8.48)$$

Assuming that no competitors since $n_A = n_B = 0$, α^* can be further simplified:

$$\alpha^* = (a_A - c_A) - 2b_A x_A^2 \quad (8.49)$$

Moreover, inserting the optimal knowledge production of the centre of excellence A α can be defined:

$$\alpha^* = (a_A - c_A) (1 - 8b_A (a_A - c_A)) \quad (8.50)$$

Once the optimal α is known, the profit of the multinational company as a whole may be derived:

$$\Pi_H^{di} = \frac{((a_A - c_A) + (a_B - c_B) + (\alpha + \varphi\alpha)x_A + 2\varphi(1 - \alpha)(x_H - x_A))^2}{4b_A} - \frac{x_A^2}{2} \quad (8.51)$$

$$\Pi_H^{di} = \frac{((a_A - c_A) + (a_B - c_B) + (\alpha + \varphi\alpha)x_A + 2\varphi(1 - \alpha)(x_H - x_A))^2}{4b_A} - \frac{x_A^2}{2} \quad (8.52)$$

Chapter 9

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