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GLOBALIZATION OF PHARMACEUTICAL R&D

Pharmaceutical R&D governance forms in People's Republic of China

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in International Business

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1 INTRODUCTION

1.1 Background to the Study

Research and development (R&D) is the process of creation of new knowledge and know-how via a controlled process as opposed to relying on chance (Brockhoff 2003). The purpose of the controlled process is to increase processes' efficiency and ability to innovate (Brockhoff 2003). Firms' survival and success, which are dependent on its ability to innovate, to create knowledge and to capitalize on inventions and know-how, is in essence directly linked to its R&D process (Dunk and Kilgore 2001). Firms' internal R&D capabilities are in many industries often viewed as critical determinants in its ability to get ahead in competition (Pisano 1990). Especially in technology driven industries there are significant positive returns to R&D investments through introduction of new or improved products and services (McEvily and Chakravarthy 1999). Technological lead and its transformation to innovative products as fruits of corporate R&D can be seen as a monopolistic advantage that helps enterprises to compete in today's market (Lall 1980). Similarly Schumpeter (1942) noted how previous R&D investments on innovations are harvested through temporary monopolistic profits (Gassmann, Enkel, and Chesbrough 2010; Freeman 2003). This type of competitive advantage can be derived from corporation's ability to link or integrate its subsidiary activities across geographic locations (Porter 1986, 1820). As the R&D function is central to the economic success of a company (Ghoshal and Bartlett 1988), its study and coordination needs to be on the top agenda for management and researchers alike (Cheng and Bolon 1993).

Historically research and development has been one of the core functions that needed to be kept in the home base or home country (Creamer 1976; De Meyer and Mizushima 1989; Terpstra 1977). The shift to globally dispersed foreign-based R&D by multinational corporations has been one of the most significant changes in their operations and represents complete change to traditional thinking on the need to centralize core corporate functions to national headquarters. Already in the 1930s portion of R&D was conducted overseas by the largest European and US multinational corporations (Cantwell 1995). After this, globalization of R&D has progressed in three phases, with early expansion in the 1960s and 1970s. This was followed by a second expansion in the 1980s and 1990s with a more emphasis on strengthening overseas R&D. In the period from 1985 to well into the 1990s the proportion of foreign R&D to total R&D expenditure increased steadily with some industry groups, such as chemical industry, pharmaceutical industry and machinery companies, allocating large percentages of their R&D budgets to foreign-based R&D (Cheng and Bolon 1993). This is a trend that has only intensified in the 21st century and shows no signs of subsiding with the third phase of global expansion ongoing according to study by Lewin and Peeters (2006).

As globalization of R&D is intervened with the changes in global economy of the 21st century, emphasis has to be put to understand the globalization of R&D and identify its key determinants. Such research on the factors influencing globalization of R&D have to do with company's motivations and reasons behind decision to establish R&D subsidiaries across borders and related to the growth of R&D globalization. Although some studies have reported individual or sets of influencing factors as explaining increased investment on R&D globalization, they have not been conclusive and the research has thus far been fragmented. Studies (Kay 1979; Miller 1977; Vernon 1977, 41-45; Dunning 1999, 61-79; Lall 1980, 102-122; Hirsch (1976), 25,70; Creamer 1976, 35,5) have emphasized factors derived from rational-economic theory and relying on profit-maximization hypothesis, which have been argued not to be suitable in explaining R&D activity notwithstanding the relevance of rational-economic theory on global dispersion of manufacturing activity (Lall 1979). While some studies argue that access to vast skilled labor pools and centers of excellence to be the driving factors (Bardhan 2006) other studies indicate the R&D cost differentials between countries to be the major expected benefit (Norwood et al. 2006).

Contrary to the findings presented in above mentioned articles is another perspective offered by Ronstadt (1977). Ronstadt (1977) argued that globalization of R&D activities follows an evolutionary path from supportive role of sales and manufacturing to technology development which, later researchers have argued to be part of the internationalization process (Boutellier, Gassmann and Zedtwitz 1999a). This view has been shared also through a historical examination of pharmaceutical industry's development, which points how from the early offshoring of manufacturing decades ago the phenomenon has travelled up the value chain from manufacturing, through back office operations and services, to include research and development, now representing the whole gamut of value creation (Bardhan 2006). Buckley and Casson (1976, 53-54) argue that instead of evolutionary process the phenomenon is due to decreasing communications costs and development of educational capacities overseas, which relocates R&D work to places where costs of non-tradable production factors are cheapest. Similarly to how the key determinant behind globalization of R&D has eluded researchers, has the factors emerging from industry level studies been inconsistent with firm level studies (Hewitt 1980; Hewitt 1983; Pearce 1989), complicating reporting of reliable results.

Some studies have grouped factors influencing R&D globalization to frameworks such as Boddewyn's (1985) framework of conditions, motivations, or precipitating circumstances or Kuemmerle (1999) with his division of influencing factors as home-base-augmenting (HBA) and home-base-exploiting (HBE). In their classification of company's involvement in foreign R&D, von Zedtwitz and Gassmann (2002) presented factors as those related to access to markets and customers or those related to access to local science and technology while at the same time they notified the inherent difference of research in comparison to development and its effect on the R&D globalization process.

This type of classification based on multiple factors has been able to explain the phenomenon a bit more and structure it as a question covering multiple variations of the same phenomenon.

The above mentioned classifications and the wider literature on globalization of R&D indicates that there exist multiple reasons for globalization of R&D and firms seek to capitalize on those factors that further their competitive position or organizational goals (Kuemmerle 1999a). Thus some R&D can be moved to offshore location following an evolutionary process, some activities are shifted overseas to capitalize on countries' R&D cost differentials while other functions are located across borders to benefit from other influencing factors. As companies have different reasons and pursue different benefits from the globalization of R&D (Kuemmerle 1999a), they also use different methods to capitalize on these influencing factors. One indication of this is that companies can be divided to types based on what they seek from the globalization of R&D and through what means (Gerybadze and Reger 1999; Ronstadt 1978).

This study proposes that the different ways to capitalize on the distinct benefits for globalization of R&D can thus also be seen in the light of its subconcepts as governance forms for dispersing R&D overseas as indicated by Boehe (2008). These governance forms for R&D globalization are: offshoring of R&D, offshore outsourcing of R&D and internationalization of R&D. The term off-shoring refers to the strategy of transferring activities across national borders using internal resources (Hätönen and Eriksson 2008). The practice of a firm entrusting to an external entity based in other countries the performance of an activity is commonly referred to as offshore outsourcing (Varadarajan 2008). Internationalization has been viewed as a process of increasing involvement in international markets, through building on existing activities and the growing tendency of operations to span across national boundaries (Welch and Lostarinen 1988; Westhead et al. 2007; cf. Ronstadt 1978). The three above listed concepts are innately separate, follow different motivations and require variant responses to the management of R&D. Further influencing the R&D globalization process is the separation to whether it is development activities or research activities that are to be globalized (von Zedtwitz and Gassmann 2002). Similarly as development varies from research, the different development tasks can vary from one another and different research tasks such as basic research may differ from i.e. from applied research to the same degree (Iansiti 1993; Lall 1979). Thus the actual R&D function to be globalized should be also taken into consideration. This is especially true for R&D in industries such as pharmaceutical industry, whose R&D process covers many fields of science, moves up the value chain and has very different requirements for its distinct parts (Cooke 2005). To corroborate or refute factors and their relations on the governance forms of globalized R&D an empirical study was conducted from the perspective of pharmaceutical industry managers in the case of People's Republic of China.

1.2 Research Gap

In the early research scrutinizing globalization of R&D, three assumptions dominated the research (Cheng and Bolon 1993). One was the notion of R&D as a home-country-based function, which safeguarding was paramount (Buckley and Casson 1985). Another one was the dependency of firms' global competitiveness on its ability to innovate (Franko 1989). The third one, focused on technical and scientific development taking place in hosting countries and their competitiveness globally facilitated by technology transfer on an international level (Quinn 1969; Robinson 1988). In this early research international business researchers have paid insufficient consideration on the management of R&D in multinational firms as well as on the underlying reasons and mechanisms for the process of R&D globalization (Cheng and Bolon 1993). The research findings of past research on R&D globalization's management was allocated by Cheng and Bolon (1993) into five strains of research. These are research on: site selection for R&D unit, local autonomy granted to subsidiaries in the light of centralization/decentralization of management, international coordination of multinational R&D, organizational structure for globalized R&D, as well as the human resource management of geographically dispersed R&D units (Cheng and Bolon 1993).

The location of overseas R&D subsidiaries were found to be in countries where the parent company already had considerable presence whether in marketing or manufacturing, or even both, according to studies with a focus on site selection (Ronstadt 1977; Behrman and Fischer 1980; De Meyer and Mizushima 1989). Concentration of advanced technology resources has also been argued to be an important site selection characteristic (Cheng and Bolon 1993). Government regulations in the target country were also reported to be reasons for location selection (Behrman and Fischer 1980; De Meyer and Mizushima 1989). This stream of research has also focused on the importance of company's country of origin in site selection and tendency to globalize parts of its R&D process, with comparisons of European and US companies involvement in overseas R&D (De Meyer and Mizushima 1989) similarly as on the globalization of R&D by Japanese firms (Behrman and Fischer 1980; De Meyer and Mizushima 1989). Nevertheless in his study Ronstadt (1977) reported that different criteria on site selection were not behind overseas R&D investment decisions.

Management of globalized R&D has also been studied from the point of centralization/decentralization, which was used by Behrman and Fischer (1979) as division criteria in separating companies into four groups. Other studies found this to be related to company's general approach on centralization, where time considerations on the completion of the project were shown to play a part alongside R&D unit's size (De Meyer and Mizushima 1989). These studies have also put forward a number of internal company related and external factors that affect this process although focusing on the management of dispersed R&D and not strictly on the factors influencing the decisions

whether and why to pursue a globalized R&D structure. Thus their contributions have to be taken into account as well when analyzing influencing factors presented in the literature on globalization of R&D, which are discussed in chapter 2 of this paper.

Continuing from the early research and building on research concerning existing factors this research attempts to corroborate the findings already presented in the literature and scrutinize the phenomenon in the distinctive context of China and pharmaceutical industry. The research is grounded on the field of international business (Mudambi 2007). Its context is the international pharmaceutical companies and the international distribution of their core activities. Its geographical focus is on the People's Republic of China (PRC), world's second largest economy. The field of corporate research and development as well as pharmaceutical discovery is central to this study. It is also related to the study of innovations by having high technology products and value creation via globally disaggregated R&D value chain as its central focus (Kotabe and Mudambi 2009). From the above mentioned standpoint this study attempts to diminish deficit areas on the subject of globalization of R&D in research to date. The following research gaps were identified:

Majority of studies on globalization of R&D consist of macroeconomic surveys (Gerybazhe and Reger 1999). Sectoral studies focus on the IT-industry while there is insufficient research on the pharmaceutical industry especially more specific, pharmaceutical product discovery and development process related investigations, which would take into account the inherited differences of research and development and those between different stages of the drug discovery R&D process (cf. Iansiti 1993; Lall 1979)

Regarding the geographical focus of studies, most studies are concentrating on the US, Japan and Europe (Gerybazhe and Reger 1999), with increasing focus on India, South Korea and Taiwan while less emphasis has been placed on the study of sifting R&D activities to China, with contributions only from a few researchers (Gassman and Han 2004; von Zedtwitz 2004; Sun 2007).

Many of the frequently cited studies in the past research are built on an old paradigm of the multinational enterprises' management and control (Buckley and Casson 1985; Bartlett and Ghoshal 1989; 1990; Hedlund 1993), which do not take into account the networked nature of today's pharmaceutical development and emphasis on sourcing or dispersion of value activities and R&D diversity in drug discovery (Su 1994; Chen and Hung 2010) based on the new paradigm (Gerybazhe and Reger 1999). Also as stated, there seems to be a gap in literature covering the subject on the suitability of different parts of drug discovery in regards to globalization of R&D.

Majority of studies (Boehe 2008; Grossman and Hansberg 2006;2008; Zheng and Xiong 2008; Håkanson, Hu 2007; Bardhan 2006; Lewin and Peeters 2006; Norwood 2006; Bardhan and Jaffee 2005; Markuse 2005; Gassman and Han 2004; Grossman and Helpman 2003; von Zedtwitz and Gassman 2002; Davis 2000; Gassman and Zedtwitz 1999; Gerybazhe and Reeger 1999; Florida 1997; Reddy 1997; Hendry 1995; Beck-

mann and Fischer 1994; Quinn and Hilmer 1994; Clark and Wheelwright 1994; Nobel 1993a,b; Kogut and Chang 1991; Howels 1990b; Kuemmerle 1990; Boddewyn 1985; Buckley and Casson 1976) in the field of R&D globalization handle pull factors that attract R&D investment to certain locations. While many of these studies are macro economically and academically important, majority of them contribute very little to the managerial aspects. Similarly management studies such as De Boer et al. (1998) along with Gassmann and Han (2004), which deal with the day to day cultural, institutional and language barriers for a successful management in geographically and culturally distant locations that are insightfully helpful in preparing managers for these problems, contribute again little to operational arrangement and beneficial corporate structures. Thus these studies hardly connect to the findings on R&D globalization factors, although some studies provide analysis of established companies based on factor frameworks, but these studies do not fully answer to the problems arising from the establishment of R&D globalization and adoption of suitable governance form. Therefore a gap in literature seems to exist in how the benefits of these literature derived factors could be most efficiently capitalized depending on the governance forms as depicted by Boehe (2008).

1.3 Definition of Key Concepts

Jargons and acronyms replete the field of sourcing and distribution of business activities, with even widely used terms "outsourcing" and "offshoring" being poorly defined or inaccurately used by managers and academics alike (Oshri et al. 2009). An explanation to this conceptual disarray could be found on the interdisciplinary background of global R&D management, which spans disciplines such as, management, international business, engineering and natural sciences. To analyse the current literature on R&D globalization and the influencing factors associated with it as well as the different strategies of shifting operations beyond borders to different geographical locations to pursue this globalization, a number of key concepts have to be defined. First of all the term *sourcing* has to be explained, as by its scope and definition almost any firm is involved in some sort of sourcing arrangement. It is defined by Oshri et al. (2009, 2) as:

"Sourcing is the act through which work is contracted or delegated to an external entity that could be physically located anywhere. Sourcing encompasses various in-sourcing and outsourcing arrangements such as offshore outsourcing, captive offshoring, near shoring and on shoring."

The act of shifting organizational activities to another country other than that of the corporation's home country can essentially be divided into offshore outsourcing, off-

shoring and internationalization based on the factors affecting the decision, which as a whole has been termed as the globalization of organizational activities in this paper. Thus *globalization of R&D* is an umbrella term that covers *R&D offshore outsourcing*, *R&D offshoring* and *R&D internationalization*, which are micro economic concepts. The macro economical concept Globalization of R&D is used in literature to illustrate the phenomenon on a country or industry level (Niosi 1997; Serapio and Dalton 1999; Li and Zhong 2003; von Zedtwitz et al. 2004; Sun et al. 2007; Florida 1997). Globalization of R&D has been discussed extensively in different fields of literature, such as studies in international business journals (Di Minin and Bianchi 2011; Zhang et al. 2007; Florida and Kenney 1994; Sun et al. 2007; von Zedtwitz 2005; Pearce 2005; Reddy 1997; Nieto and Rodríguez 2011; Hotz-Hart 2000; Mendez 2003; Song and Shin 2008; Sun and Wen 2007;) and in papers from top journals concentrating on innovation studies, policy and management (Serapio and Dalton 1999; Florida 1997; Gerybadze, and Reger 1999; Dunning 1994; von Zedtwitz and Gassmann 2002; Kuemmerle 1999; Carlsson 2006; Athukorala and Kohpaiboon 2010; Petrella 1992; Uzunidis and Boutillier 2012; Dunning and Lundan 2009; Feinberg and Gupta 2004), as well as in journals dealing with technology or R&D management (Manuel et al. 2000; Casson and Singh 1993; Bardhan 2006; Reddy and Sigurdson 1997; Moncada-Paternò-Castello et al. 2011) along with governmental and institutional publications (Lundin et al. 2007; Foray 2006; Reddy 2002; Golnam et al. 2007; Barr and Tessler 1996; Åkerblom and Luhtala 2006). Various authors have used terms such as geographical decentralization of R&D (Di Minin and Bianchi 2011; Buckley and Casson 1998; Cheng and Bolon 1993; Casson and Singh 1993; von Zedtwitz et al. 2004; Håkanson and Nobel 1993; Fischer and Behrman 1979; Nieto and Rodríguez 2011; Contractor and Sagafi-Nejad 1981) or dispersion of R&D (Lamin and Livanis 2013; Phene and Almeida 2008; Adler and Hashai 2007; Kuemmerle 1999; Rugman and Verbeke 2003;) to illustrate the same phenomenon, for simplicity in this paper the author has used globalization of R&D to cover all these three terms.

In this paper as an actual arrangement of operations, internationalization of R&D and offshoring of R&D includes the in-house execution of R&D activities. The abroad contracting out of R&D activities and centers is termed offshore outsourcing. Before conceptually separating these three terms the author states that in this paper the following definitions are used. *R&D internationalization* has been viewed as a process of increasing involvement in international markets, through building on existing activities and the growing tendency of operations to span across national boundaries (Welch and Lostarinen 1988; Westhead et al. 2007; cf. Ronstadt 1978). The term *offshoring* characterizes a strategy of transferring activities across national borders using internal resources (Hätönen and Eriksson 2008). The practice of a firm entrusting to an external entity based in other countries the performance of an activity is commonly referred to as *offshore outsourcing* (Varadarajan 2008).

A clear distinction should be made between offshoring of R&D and be the general internationalization of R&D, due to the different logical underpinnings of these concepts (Boehe 2008). Companies generally acknowledge that their international expansion is a continuum of small steps to be taken in order for a gradual adaptation into the host country's unique market environment to happen (Ronstadt 1978). Several drivers have been suggested as the logic behind R&D internationalization, such as market-drivers (market size, strategic clients or lead markets), as well as technology –drivers (production facilities or science, world centers of excellence) in cutting-edge research (Boutellier, Gassmann and Zedtwitz 1999). This is a striking contrast to the logic given by the transaction cost economics respectively for offshoring, which has been stated to be motivated by labor and technology considerations and other factors, such as cost considerations (Norwood et al. 2006).

General understanding of offshoring (Boehe 2008) is stated as shifting value-chain activities abroad from the home country. Another common usage of the term is the relocation of organizational activities to an in-house subsidiary, also titled captive offshoring (Boehe 2008). This is nevertheless challenged by Norwood et al. (2006, 35), who makes the case that:

“There is no clear, universally accepted definition of what constitutes offshoring “

They (Norwood et al. 2006, 8) nevertheless say for the underlying reason for offshoring to always be the same by stating that:

“Virtually all of the studies examining business offshoring decisions and their anticipated benefits identify cost savings as the leading expected benefit.”

The above mentioned are loose definitions, which are more clearly elaborated by a strict and broad definition of the concept (Boehe 2008). The value of the loose definition has to do with the promising reduction in cost that comes from moving organizational activities to a location with favourable business conditions.

The strict definition requires a shutting down of a home location and the consequent overseas transfer of existing economic activities (Hertveldt et al. 2005, 9; Boehe 2008). A broad definition of offshoring forfeits the closing down of a home location requirement. This is due to three scenarios, the home site may take on other activities or the home site's abandonment may only happen after a time (Boehe 2008). A third scenario is that a company may decide instead of expanding in its home country to establish business in an offshore location instead (Hertveldt et al., 2005,9). A specialized case of offshoring is nearshoring, which is the relocation of organizational activities to a neighboring country and onshoring that refers to moving operations to another inhouse facili-

ty within the original country (Oshri et al. 2009). In this paper nearshoring is included to the broader definition of offshoring and due to the international business standpoint of this study onshoring isn't considered.

Similarly it is also worth noting that offshoring is conceptually distinct from outsourcing. Outsourcing is defined as the intent of shifting value chain activities to an external generally legally independent entity, which can be located at home or abroad (Boehe 2008). A more functionalistic definition by Oshri et al. (2009, 4) states outsourcing as follow:

"Outsourcing is defined as contracting with third service provider for the management of completion of a certain amount of work, for a specified length of time, cost, and level of service."

Very often outsourcing relationships are short-term, arms-length relationships between a contractor also known as customer and the service provider also known as a supplier. This interaction generally involves passing of designs, prototypes or test specifications by the contractor to the supplier, which in accordance to the contract provides the contractor with components, products or test results.

However, offshoring may be combined with outsourcing, which is termed offshore outsourcing and refers to a situation when an activity is carried out by another organization in another country (Boehe 2008). Where in offshoring the functions are performed in a foreign country by a foreign wholly owned subsidiary, offshore outsourcing in contrast refers to a situation where an external organization performs business functions on behalf of the company in a country other than the one where the products or services are actually developed or manufactured. Here worth noting is that a cooperative agreement or joint product development implies longer term relationship and is considered in this paper as offshoring if and as it usually involves direct investment. For this kind of networked business model where both partners work in an integrated manner is a grey area between offshoring and offshore outsourcing, as it often involves intense long-term, rather than short-term interaction, focused on jointly creating new knowledge, new technology or a new product (Ford et al. 2003).

As stated the globalization of R&D can be arranged by means of internal (captive or in-house) or external (outsourcing) delivery models (Oshri et al. 2009, 4) and R&D offshore outsourcing and R&D offshoring follow different logic than R&D internationalization (Boutellier, Gassmann and Zedtwitz 1999). Thusly R&D offshore outsourcing can be contrasted with both the internationalization of R&D and offshoring of R&D as rationales behind overseas sourcing of R&D operations to support firms domestic and global organization. Similarly, as these concepts are distinguishable from each other. In this paper the broader definition of offshoring and offshore outsourcing are adopted to

represent those geographically dispersed R&D operations that are not part and not motivated by the same reasons as the general internationalization of firms R&D.

Characteristics of all of above mentioned three strategies of going beyond borders can also be scrutinized in the light of the "traditional view" or "traditional paradigm" of R&D globalization versus the "new paradigm of transnational innovation" and the underlining factors driving these two views. In the worldview of "traditional paradigm" technological and scientific knowledge base and product concepts are derived from a single dominant home location; the fruits of which are then later reproduced in peripheral locations (Gerybadze and Reger 1999). This process of primary flows of information and knowledge from the central locations to the periphery leads to one-way technology transfer, outward learning and exploitation of knowledge with a very little knowledge based added value in the peripheral locations (Gerybadze and Reger 1999). As this is how the world looked like in the 1970s, a period in history that was characterized by US superiority in almost all fields of science and technology.

The new paradigm is a striking contrast to this with an focus on market and technology interaction in all locations, multiple centers of knowledge at differing geographical locations around the globe that participate in knowledge sharing through inward and outward learning in opposition to one way information transfer combined with a global integration of number of actors along the value chain through cross-functional learning (Gerybadze and Reger 1999). The view is illustrated by the fact that in all major fields of science and technology two or three centers of excellence exist today with an intense competition and frequent changes in order among them (Cooper 2005).

When analyzing the globalization of R&D, the widely used abbreviation R&D has to be defined as well as the distinction between what is considered R in relation to D. In the 2008 OECD Factbook, the phrase *research and development* (R&D) is depicted as:

"creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD 2008).

This OECD definition of R&D is the one used in this study to indicate the whole R&D process. A more general compressed definition of R&D refers to the process of development of either: new knowledge, products or services to an entity such as a company. A common definition of research is the process of discovering scientific knowledge, which has the potential to further the development of commercially viable manufacturing processes and products by acting as a technology platform (von Zedtwitz and Gassmann 2002), a definition of research used in this paper as a clarification. Different concepts and definitions exist also on product development processes. One of them, supported by operations researchers seems to agree that its heart constitutes the design-build-test cycle (Clark and Fujimoto 1991; Wheelwright and Clark 1994). Inte-

gral part of this cycle is the building of either virtual or more often physical prototypes from a new product design at the design stage. Various testing is then performed for the prototypes, after which the test results are fed back to supplement the design stage. The cycle may be repeated until a satisfactory results are obtained or until the new product design is abandoned. Another generally accepted but a looser definition characterizes development as the process of applying a technological platform to the creation of new commercially viable production processes and products (Medcof 1997). The author has chosen to use this looser definition of development in this paper, as it is based on conforming ideology with the definition of research adopted by the author.

1.4 Purpose of Research

A motivation for this research comes from the phenomenon presented in numerous industry white papers and in the academic literature on the need to increase productivity and enhance profitability of the industry by geographically dispersing pharmaceutical R&D. A notable development in the industry is the need for pharmaceutical companies to limit their R&D costs and increase the productivity of R&D due to declining revenues from the expiration of the 25 most significant drug patents (DeRuijter and Holston 2012). This research attempts to show how companies can capitalize on advantages that are derived from the influencing factors depending, which governance form they employ and what portion of drug discovery processes R&D they plan on conducting in China. The purpose of this research is to identify factors influencing the globalization of pharmaceutical R&D in PRC and how these factors affect the different governance forms on a continuum of pharmaceutical drug discovery. This research attempts to fulfill the above mentioned purpose by answering to the following research question:

"How to determine the appropriate governance forms for globalization of pharmaceutical R&D for international pharmaceutical companies in the context of PRC based on the influencing factors?"

The research question is divided into the following subquestions with the objective that when the subquestions are answered they will provide a complete and coherent answer to the main research question:

"What are the different factors influencing the internationalization of pharmaceutical R&D to PRC?"

"What are the different factors influencing the offshore outsourcing of pharmaceutical R&D to PRC?"

“What are the different factors influencing the offshoring of pharmaceutical R&D to PRC?”

“How does the continuum formed of pharmaceutical drug discovery's stages influence the globalization of pharmaceutical R&D in the context of PRC?”

In order to answer the above mentioned research question an empirical qualitative research was conducted in China. The research is based on 8 qualitative expert theme interviews with local pharmaceutical directors and managers conducted in 2011-2012, utilizing theme interview method with few standardized guiding open ended questions and validating findings using a semi-structured research questionnaire. The research is confined to the R&D operations conducted in China by International Pharmaceutical companies, their R&D departments/subsidiaries or their contract research organizations (CRO). The international pharmaceutical industry, with 2009 market size of \$808 billion USD today is dominated by 12 large MNCs that form the Big Pharma as depicted by fortune 500 report (CNN, Fortune 500 2009). The Big Pharma is further augmented by over 30 large and close to a 100 medium sized companies (IMAP 2011). The industry is formed with the addition of over a thousand biotech companies since the 1990s, of which an over 100 have become essential parts (Cockburn 2004). Many of the smaller and medium sized pharma and biotech companies are service providers such as contract research organizations (CRO), contract manufacturers (CMO), ingredient manufacturers or active pharmaceutical ingredient (AIP) developers and producers (Su 1994; Chen and Hung 2010).

This study is further limited to only those pharmaceutical companies that have average R&D intensity on the company level or at minimum on the business level equal or higher than 10% as indicated by the University of Tottenham's Database on International R&D Investment Statistics (INTERIS) and ISI Database on International Research and Innovation Activities (ISI-DORIA). Choosing this company inclusion criteria in the research enables the scrutiny of R&D as independent from other functions of the company (Cantwell, 1994, 8) and is a criteria used in other studies on the field, which validates comparisons (Gerybadze and Reger 1999; Meyer-Krahmer and Reger 1999).

Concerning the globalization of R&D activities interesting path of research has focused on the role of communication and knowledge sharing on the success of globalized decentralized R&D (Leifer and Triscari 1987). This research do not dwell on the need of large transnational firms to establish efficient internal communications or mechanisms of knowledge sharing except from the point of whether it is a factor affecting the decision to whether move R&D and why to move R&D to foreign countries.

Similarly some research on globalization of R&D has focused on the location decisions and criteria for site selection. These are not considered in this research except for

the specific location factors related to PRC on account they are included as a factor influencing the decision whether to move R&D and why to move R&D to foreign countries (Gassman and Han 2004; von Zedtwitz 2004).

The structure of this paper includes an introductory first chapter, which consist of the background to the R&D globalization phenomenon, an illustration of the early research on R&D globalization, while compiling it to influencing factors handled by present research. Furthermore the first chapter defines some key concepts, states the purpose of this study and the research problem. In the second chapter the history of R&D globalization and its characteristics are chronicled followed by a more contemporary literature review of the research on the influencing factors on R&D globalization to date. The chapter is continued with a recount of the most influential factor frameworks presented in the literature, together with analysis on their theoretical contributions and a comparison of the frameworks. The chapter is completed with a presentation of the field of study and how the intrigues of pharmaceutical industry and the specific environment of People's Republic of China impact the influencing factors identified in the literature, along with a description of the pharmaceutical drug discovery process and the chapter findings are summarized in an initial framework. The third and next chapter acquaints the reader with the methodology and methods used in this study while the fourth chapter presents the results and findings of the empirical research. The fifth and last chapter presents the author's conclusions, together with their theoretical and managerial implications.

2 LITERATURE ON GLOBALIZATION OF R&D

2.1 History of R&D Globalization

There is both academic research emphasis as well as interest from the business community and governmental decision-makers towards *globalization of R&D* (Gerybadze and Reger 1999). As it is not a new phenomenon and a one that represents the most significant change in traditional corporate thinking it is surprising that the research on it remains fragmented and theoretical contributions are still lacking. As reported in a study by Cantwell (1995), already in the 1930s the largest European and US multinational corporations had shifted about 7% of their R&D to overseas. In 1960s and 1970s was a period of strong global dispersion of corporate activities, which led to companies setting up factories and sales operations in foreign countries. These operations were already in the mid-1960s accompanied by significant foreign R&D conducted by MNCs according to US tariff commission's 1973 report (Lall 1979). In 1980s this trend intensified as these foreign subsidiaries started being supported by design and development geared towards adapting products and processes to local requirements (Gerybadze and Reger 1999). A significant part has also played the convergence of IP protection for example with the adoption of The Patent Cooperation Treaty of 1978, which enables the usage of uniform format patent application applicable in all of the participating countries (Boddewyn 1985).

As the globalization of R&D became a stronger trend in the 1980s, its significance continued to grow in the 1990s, with large multinational firms augmenting the dispersion of innovation activities globally (Patel and Pavitt 1992; Cantwell 1994, 15-23; Nonaka and Takeuchi 1995, 197-210; Roberts 1995a,b). De Meyer and Mizushima (1989) also reported that heavy investment by Japanese firms in manufacturing facilities overseas was by the process of globalization subsequently leading to development of "peripheral activities" that supplemented manufacturing facilities, firstly activities such as process and product engineering, followed by more complex R&D operations. In the mid-1980s and well into 1990s corporations strengthened their foreign R&D activities. This trend of multinational companies extending their R&D competences on to a global scale was influenced by the emergence of coherent national innovation systems and increasingly sophisticated markets in the receiving countries of Organization for Economic Co-operation and Development (OECD). The implications for R&D management were that gradually the foreign R&D centers, previously occupied with the exploitation and adaptation of centrally developed home country-based technologies, became integral parts of the R&D network by being involved in exploration and advanced development (Gerybadze and Reger 1999).

A survey by Lewin and Peeters (2006), depicting the major functions to be globalized of 90 companies from the 650 US Forbes Global 2000 companies, found major increases (81% growth rate) in the future plans for offshoring of research and development that indicates for the third global expansion of R&D globalization to be ongoing.

R&D internationalization and offshoring in some ways resembles the offshoring of manufacturing, in that it has potentially high capital requirements but at the same time it bears some similarity to services offshoring; which usually is not at all capital intensive but has high requirements on the white collar job market and affects multitude of different white collar occupations simultaneously (Bardhan 2006). This is in contrast to the low skill uniform blue collar labor requirements of manufacturing. Manufacturing has traditionally shifted purely to countries that offer low-cost production opportunities such as the East Asia, while services have traditionally favored the English speaking, institutionally compatible old British colonies of the Commonwealth of Countries such as India and Bangladesh (Bardhan and Kroll 2003). Globalization of R&D has traditionally progressed according to the changes in cutting edge scientific development and networks offered in different parts of the world (Cooke 2005). Intensification of global competition has forced companies to seek spending cuts at all cost centers leading R&D globalization to the search of equal portions of low cost and availability of vast skilled scientific talent pools in China, India, Russia along with many of the former Eastern European socialist countries (Bardhan and Jaffee 2005).

Furthermore some research states that MNCs increasingly off-shore product development activities completely according to a simple formula of the difference between incurred coordination costs and savings on operational costs. Buckley and Casson (1976, 53-54) state that all R&D work should be located to regions where costs of non-tradable production factors were cheapest and educational capacities most developed in the absence of communications costs. They show how the increase of R&D capabilities in the low and medium cost emerging countries, together with innovations in ICT leading to decreasing coordination and communications costs, enhance the probability that R&D work is shifted or dispersed from high cost to medium or low cost countries (Buckley and Casson 1976, 53-54).

2.2 Factors influencing Globalization of R&D

From the history of R&D globalization it is evident that many factors influence this phenomenon. Gerybadze and Reger (1999) suggested in their empirical study conducted between 1994 and 1997 for a number of reasons to be behind this development in globalization of R&D. Such reasons as: the effect of *national innovation systems*, *fiscal consolidation* of R&D, *changes in the management* of R&D, design of systems for *commu-*

nication and knowledge sharing, *network externalities* in advanced markets and manufacturing systems, technology and options seeking activities in R&D as well as desire for *inward learning* that requires presence in most technologically and scientifically sophisticated locations. Similarly in their paper they illustrated a change that started in the 1990s with R&D management being rethought in major multinational companies that were undergoing managerial changes in R&D. These managerial changes resulted from the increasing problems of coordination related to building-up of regionally distributed intra-corporate R&D structures and their embedding into worldwide R&D co-operations and strategic alliances (Gerybadze and Reger 1999).

The preliminary findings by Gerybadze and Reger (1999) suggest that factors related to Globalization of R&D have to be seen as those impacting on the macroeconomic level and those that are micro economic factors impacting on the firm level. Macroeconomic factors are those such as the effects of *national innovation systems*, availability of *labor*, *fiscal consolidation* of R&D and *cross country cost differentials* together with the changes in the world economy and growing importance of some *markets* in the developing countries (Granstad, Håkanson and Sjölander 1993). Another set of macroeconomic factors are those presented by Boddewyn (1985) as conditional factors, which can be seen as basic requirements for setting up any R&D operations in a country. Such factors are for example the necessary *infrastructure* in the country, starting from the supply of electricity and clean water to all the way to the structure of country's tertiary education. Similarly according to Boddewyn (1985) the *legal framework* in the country creates a basic condition for a company, whether it can shift so high value activities, products or technologies to a given country. According to Granstad et al. (1993) micro economic factors in turn are those that affect decision making mostly on the level of individual companies, such as *managerial changes* and inducements from high-end *markets* or *production* environments as well as individual *financial incentives* or strategic alliances with *expertise centers* or research groups and professors. In the following sub chapters both the micro- and macroeconomic factors derived from the literature are divided according to their operational focus to R&D as: labour factors, financial factors, market consideration factors and risk factors, which are then summarized in table 1 together with the authors reporting them in alphabetical order.

	Bardhan&Jaffee 2005	Bardhan 2006	Beckmann and Fischer 1994	Bocklewyn 1985	Boche 2008	Bucky and Casson 1976	Davis 2000	Gassman & Han 2004	Gassman and Zedwitz 1999	Geryhazhe&Reeger 1999	Grossman and Hansberg 2006;2008	Grossman and Helpman, 2003	Florida 1997	Howels 1990	Håkanson ;Nobel1993	Hu 2007	Hendry 1995	Kogut and Chang, 1991	Kuemmerle, 1990	Lewin and Peeters, 2006	Markuse, 2005	Norwood, 2006	Quinn and Hilmer 1994	Reddy, 1997	Von Zedwitz and Gassman 2002	Wheelwright and Clark, 1994	Zheng and Xiong 2008
R&D labour pool	X	X	X	X				X	X	X																	
Scarcity of R&D resources			X	X				X	X																		
Labour market structure		X	X																								
Centres of Excellence			X	X				X	X																X		
National innovation systems				X						X																	
Development of LEDCs			X	X						X																	
Local science and technology			X					X	X	X											X			X	X		
Tech&infrastructure incentives								X																			
New technology output		X						X																			
(a)/synchronous development			X		X	X				?																	
Cost differentials						X	X			X										X		X		X			
Policies&financial incentives				X				X			X					X											
Fiscal consolidation										X																	
Operational efficiency																			X								
Nontradeable production costs						X																					
Home country requirements												X				X											
Access to local markets	X	X							X	X															X		
Regional market requirements								X																	X		
Market/product adaptation		X	X							X			X	X													
Local requirements		X								X																	
Decreased time to market																										X	
Customer&sales information			X						X																X		
Country intelligence&market entry	X											X	X				X			X					X	X	
Inward learning	X	X	X						X			X					X										
Local presence	X	X	X																								
Peer pressure			X																								
Oversear manufacturing pull			X																X						X		
Offshored production			X																X								
Manufacturing R&D, field eng.																			X						X		
Precipitating circumstances		X	X		X				X																		
Convergence of IP			X																								
Improvement in infrastructure		X	X																								
ICT improvement and cost		X							X																		
Higher education		X		X																							
Risks																											
IP protection and data security			X																	X							
Poor quality/quality control																											
Weakening morale, Insecurity																	X		X								
Infrastructure&political instability		X	X																X								
Supplier becoming a competition																						X					

Table 1. Influencing factors on globalization of R&D from literature with their authors

2.2.1 *Availability of labor and centers of excellence*

Gerybadze and Reger (1999) point on the growing sophistication of *national innovation systems* in OECD countries during the 1980s and 1990s as facilitators of polycentric learning environments that lead to multinational corporations to extent their R&D networks to many new non-typical R&D locations outside US and Western Europe. By spawning a leading *center of excellence* in a relevant field of science and technology a national innovation system forces multinational corporations (MNC) to source talent and know-how outside their home base in order to stay competitive. Gassmann and Han (2004) highlight that the difficulty of attracting best international talent to overseas destinations, forces companies to establish R&D facilities to locations where highest expertise and facilities are available. Beckmann and Fischer (1994) add that private facilities as well as public institutions, such as research centers and universities, function as local sources of engineerial and natural science knowledge along with technical spill-over. Together these public and private actors form local pockets of innovation, which are geographically as well as academically defined expertise areas, characterized by high know-how potential. Also as the core of informal expertise network, they facilitate sharing and processing of knowledge and information in the early phases (Beckmann and Fischer 1994).

In general, it can be said that such local pockets-of-innovation are spawned with the formation of excellence centers or science parks, which attract investors by providing space, advanced infrastructure, and sorely needed high-tech facilities along with financial incentives (Gassmann and Han 2004). Gassmann and Han (2004) affirm that generally companies have been attracted to shift overseas parts of their R&D operations to regions characterized by a high rate of *new technology output* or *centers of excellence* in hopes of greater advantageous spill-over potentials. Shifting R&D overseas to target country may also be beneficial for acquiring applicable *sciences & technologies* such as those related to safety measures and standards (Beckmann and Fischer 1994).

In the future the role of publicly financed research will expand brought upon by scientific advancement that increases potentially relevant research fields (Leifer and Triscari 1987). Thus the importance placed on centers of excellence formed by universities and research centers will continue to expand. Worth to note that cost considerations and financing play a part in steering particular research or technologies to defined areas as in recent years the costs of basic R&D have risen sharply simultaneously when public financing for R&D has stagnated or even decreased, especially in Western countries (Beckmann and Fischer 1994). The case is further weakened by the inability of many companies to afford cutting edge R&D by themselves and then thus forced to locate and depend on the resources in places where they are available (Beckmann and Fischer 1994).

Gerybadze and Reger (1999) also list organizational innovations that are accelerating the change in R&D globalization, such as the development of *new management* solutions that allow for rapid flexible networking of institutionally or regionally scattered centers of competencies through R&D co-operations and strategic alliances (Sydow 1992; Gerlach 1993; Gerybadze 1995). These new solutions include novel arrangements for distributing R&D activities and competencies from the mother company for its suppliers and to various outside stakeholders such as universities, private research institutes and even to customers (Gerybadze and Reger 1999).

On the same note the blurring of basic and applied research as well as research in relations to development has led companies into adapting new mixed forms between basic and applied R&D that required decisive changes in the corporations' management (Iansiti 1993; Leifer and Triscari 1987). All these changes have resulted, especially in R&D intensive sectors, in wide outsourcing arrangements across the whole spectrum of value creation operations.

Another implication of this managerial change is presented in multiple studies and has to do with R&D-specific location factors e.g., the desire to access a *local talent pool* (Teece 1976; Ronstadt 1977; Mansfield, Teece and Romeo 1979; Lall 1980; Kogut and Zander 1993). A system for global technology procurement, which has enabled the distribution of R&D and facilitated learning from geographically distant knowledge centers, has been enacted in most MNCs to respond to these changes (Gerybadze and Reger 1999). *Availability of labor* for skilled R&D occupations is critical for the adoption and flourishing of offshore outsourcing, offshoring and internationalization of R&D. According to Bardhan (2006) a global labor market that comprises the whole length of R&D labor pool formed of scientists, engineers and other academic and high-tech professions is the effectively result of technological progress and politico-economic changes. Nevertheless, other considerations than labor costs and educated labor supply market are also of utmost importance. Such crucial features Bardhan (2006) says are geographical distribution and clustering of talented labor, tradition for commitment by R&D labor as knowledge assets, labor market mobility and labor laws, contractual labor provisions and practices and the practical and legal framework of intellectual property protection. Because the expertise of the personnel is paramount to R&D operation's success, great importance has to be put into the recruitment process and suitability testing as well as the continued training of employees (Beckmann and Fischer 1994).

Another push factor for R&D globalization has been *scarcity of R&D resources* for high-tech companies operating in small markets (Gassmann and von Zedtwitz 1999). Beckmann and Fischer (1994) also state that first and foremost importance for the success of the R&D mission is the availability of *advanced R&D labor pool* and the expertise of the personnel. They see that in the Western world, especially in smaller countries there is a scarcity of engineers and researchers. Shifting operations overseas, when it may be cheaper to transfer a project abroad instead of increasing the capacity back

home, may alleviate these resource capacity shortages at home (Beckmann and Fischer 1994). Even companies operating in large markets with abundant domestic R&D base have been forced to shift their R&D overseas in search of technological and scientific know-how on a global scale by increased competition within and outside their industries (Gassmann and Han 2004).

Related to the aforementioned capacity arguments, another factor which may save time and increase product development capacity termed *asynchronous parallel development* model describes how a project can be carried out at different locations simultaneously if separated into several independent components by an MNC with several R&D or product engineering units; just as they do with component production and final assembly activities (Boehe 2008). When limiting a function to one particular location or a facility, it decreases the amount and variety of competencies that could be employed for that function (Beckmann and Fischer 1994). By dividing the function to multiple locations different competencies can be accessed and synchronous although partly parallel work can be achieved (Beckmann and Fischer 1994).

The picture painted of the phenomenon in the academic literature on R&D globalization by the above mentioned authors shows the importance of national innovation systems and local high-technology clusters in the formation of centers of excellence. These actors function first and foremost on the macroeconomic level promoting a certain country or a region but also on the individual company level through the centers of excellence and the business relations, academic expertise as well as technology and infrastructure incentives they provide. Importance of centers of excellence is most evident for companies dependent on cutting edge research. Identically the aforementioned actors also supply firms with the resource paramount to their success – human capital. Availability of labor has been shown as make or break factor in decisions to establish intra corporate subsidiaries to a country while off less importance in outsourcing, affecting on micro level but dependent on macro policies, such as higher education and labor laws.

2.2.2 Cross country cost differentials and financial incentives

Another set of studies indicate for a key factor behind globalization of R&D and especially the offshoring of R&D to be the need to cut down costs that was cited by 93% of respondents as a major strategic driver in a survey by Lewin and Peeters (2006). Even though not exclusively handling R&D the survey's results are applicable, as the soaring cost of R&D are closing on the borderline of the financeability of innovation. Gerybadze and Reger (1999) report that *fiscal consolidation* is a result of the increasing costs of R&D that has many companies against the barrier of the financeability of R&D while at the same time keeping up with the "R&D arms race", a high tech competition

phenomenon extensively illustrated by von Braun (1995). A manifestation of the fiscal consolidation is both the weakening of central research as spending on fundamental research is limited and a stronger business-unit focus as the research is geared towards application orientation (Roussel et al. 1991).

As a symptom of the increasing costs, *cross country R&D cost differences* have attracted considerable attention. In fact, the cost argument has been suggested to be the major factor by preliminary empirical evidence from some studies (Buckley and Casson 1976; Norwood et al. 2006). These studies include for example, a research on US pharmaceutical companies carrying out some R&D in Denmark by Davis (2000), who found the main reason to be taking advantage of positive *cost differentials* and another by Reddy (1997), who also argue cost differentials to be the primary force. Nevertheless, financial benefits can be reaped through other means than purely through cost reduction, for example with financial incentives offered to high-tech companies by excellence centers or science parks, including three year complete tax levy following company's establishment, with a subsequent 50% discount for the next three years, and a 15% tax rate discount from the seventh year onwards, along with other tax incentives (Gassmann and Han 2004). Clearly R&D globalization is then a flexible way for evading home country's regulations and profiting from host country's policies preferential to FDI (Grossman and Helpman 2003; Hu 2007).

Contrary to studies by Lewin and Peeters (2006), Buckley and Casson (1976), Norwood et al. (2006), Davis (2000) and Reddy (1997), a great number of publications on globalization of R&D have reached the conclusion that cost is not the major factor, such as report by Gassmann and von Zedtwitz (1998) on the importance of long term strategic goals and not short term ROI considerations. According to Granstrand, Håkanson and Sjölander (1993), these direct cost advantages rarely influence the internationalization of R&D, but other efficiency factors such as costs of coordination and transfer, and critical laboratory size do have an impact on international R&D organization. However, costs can apply to industries that experience strong cost competition in relation with high R&D requirements and costs (Cheng and Bolon 1993). In more detail, majority of costs are comprised of personnel cost differences, which on average account for two thirds of costs. Thereby developing countries may appear as attractive cost centers, although *infrastructure costs* may erode these gains, which Beckmann and Fischer (1994) pointed out. They say that the state of infrastructure in a country can lack to such an extent that setting up any facilities or operations is impossible or it can be a source of extensive costs. Even though the per capita costs of employees would be beneficially low, the overall costs of R&D in a developing country can be surprisingly high and efficiency so lacking due to inhospitable infrastructure that only a fraction of cost advantages can be realized (Beckmann and Fischer 1994).

2.2.3 Access to markets, local adaptation and requirements

Another set of objectives for R&D globalization include the need to react to differential and varied environments of *product requirements*, *markets* and institutions more agilely (Grossman and Hansberg 2006; 2008). Similarly, *market size and growth* as well as the opportunity for *inward learning* from these lead markets has been reported to be major drivers in R&D globalization.

Gerybadze and Reger (1999) state that inducements from high-end markets and production environments are building blocks of the corporate R&D; capitalizing on these externalities requires R&D to take place in several of these leading locations in the world. Deriving from this, some researchers have stated that conducting R&D offshore increases the amount of *local knowledge* the firm can obtain (Howells 1990; Kogut and Chang 1991; Florida 1997), which may be achieved by organizational learning and capability building in the host country. Beckmann and Fischer (1994) argue that an overseas R&D department becomes interesting to the whole R&D structure of the company only when both the amount and sophistication of local lead users as well as the innovativeness and the number of new product introductions by local companies reaches a sufficient level.

Studies by Teece (1976), Ronstadt (1977), Mansfield et al. (1979), Lall (1980) and Kogut and Zander (1993) emphasize market characteristics, size and attractiveness of foreign markets. *Market potential*, i.e. *market size and growth*, is especially paramount in regards to company's interest in placing R&D opposed to lower value operations to that specific country and spending resources for the required *product adaptation* (Beckmann and Fischer 1994). Shifting R&D overseas to a target country may also be beneficial for quickly approaching fragmented markets (Markusen 2005; Zeng and Xiong 2008). Building on this Bardhan (2006) says that, gaining *country intelligence* and initial access for future *market penetration* can best be achieved through R&D globalization. Country intelligence and knowledge for initial access for future market penetration can potentially benefit a company also in more indirect ways: cultivation of unrelated business and *government contacts*, spillover gains to other business activities and opening up of third country markets access from locationally advantageous position (Bardhan 2006).

Beckmann and Fischer (1994) say that reacting to market environments can be based on *market adaptation* by carrying out research and designing to the market in question. Further research suggests that conducting R&D in an offshore location is integral in facilitating *product adaptation* to local markets (Howells 1990; Håkanson and Nobel 1993a,b). Competition increases the need to decrease *time-to-market*, with local R&D potentially speeding up product development. Decreasing time-to-market can reduce the costs of launching late or the costs of doing it wrong. This results in a competitive edge,

by either beating the competition in introducing a new product much sooner than others or by introducing a better product at the same time (Clark and Wheelwright 1994).

Studies by Teece (1976), Ronstadt (1977), Mansfield et al. (1979), Lall (1980) and Kogut and Zander (1993) also illustrate the need to adapt product variants to country-specific situations. Beckmann and Fischer (1994) explain how country's development and economic conditions may put pressure on the structure and content of the product and thus require product adaptation. Their study suggests also that the amount of product adaptation needed to modify the existing product into meeting the local needs also plays a factor here (Beckmann and Fischer 1994). *Local requirements* may also play a part as product's applicability to local legal requirements and standards have to be verified, which usually requires at least minor adjustments (Beckmann and Fischer 1994). To be competitive, products have to correspond to market and even to individual customer needs and requirements. The local adaptation of a product is especially paramount when introducing a novelty product to the market. The scale of required modifications depends on the variability of customer needs, local manufacturing competencies and legal requirements. Socio cultural values, differences and requirements may require product adaptation even inside geographically relatively small areas (Beckmann and Fischer 1994).

One of the main reasons for constructing technical research abroad is the difficulties in *receiving permits* from local institutions. From the author's perspective, decisive is not the permits themselves, which are often readily given in the Western world but the long time and the risks involved in them overseas. Alas, the permit times can total several years and the process requires wide open disclosure and cooperation with stakeholders. In addition, immediate costs will be increased due to delays in market entry and multiplied by high demand. (Beckmann and Fischer 1994) However, Beckmann and Fischer (1994) highlight that the important permit categories are safety measures and standards.

Beckmann and Fischer (1994) report that when a new company is establishing its first R&D laboratories and does not have previous *local presence* nor a recognizable brand, what they will be lacking is attractiveness as an employer and trust from potential customers, which decreases available capacity. A solution to this is the gradual building of operations in a country from the least value associated operations to the most value creative ones. Thus previously off-shored *production* has also been found by Kuemmerle (1999) to be a pull factor, as on site R&D facilities are needed to provide technical support. When considering capacity arguments, Boehe (2008) says that thriving for an *synchronous round-the-clock dispersed* development model through globalized R&D function is another push factor, which may also contribute to shortening development times. These gains come from the possibility that work can be continued globally round-the-clock by different people, thus critically cutting delivery times.

The market potential is closely associated with the tendency for products adaptation to markets with decreasing time-to-market, as well as with the company's interest on the overseas R&D department as a source for inward learning and local knowledge. The direct effect of market size, attractiveness and growth is whether market entry to a particular market is considered strategically significant, which warrants local presence and seeking public approval. Another factor closely associated with market interest are local and legal requirements that facilitate technology acceptance in the country, which on extreme may require local content in production or development.

2.2.4 Risk factors in globalization of R&D

In their survey of 90 companies from the 650 US Forbes Global 2000 companies Lewin and Peeters (2006) present a number of *risk factors* of offshoring, those especially related to offshoring R&D are as follow: *poor quality, loss of control, lack of data security, weakening employee morale, operational inefficiency, infrastructure instability* in host country, *intellectual property loss* and *political instability* in host country.

When it comes to outsourcing the main risk factor is that the provider may attempt to surpass the customer if the customer's core competence is not kept away and is not a real barrier to entry in to the marketplace (Quinn and Hilmer 1994). Lewin and Peeters (2006) state, that in outsourcing another risk factor is associated with a potential decrease in *cross-functional learning* and knowledge sharing. Outsourcing has been argued to also decrease the overall learning ability of the organization on the organizational areas from where the activity is outsourced as it increases insecurity, reduces willingness to question and experiment thus reducing innovativeness as well as decreases motivation of the workforce (Hendry 1995). Concerning internationalization of R&D a major risk factor worth mentioning is political and infrastructure instability, which may turn a long span strategic investment decision and gradual build up into utterly flawed (Beckmann and Fischer 1994).

Instead of outright risks some factors can be seen as *basic conditions* required for any R&D work as presented by Boddewyn (1985). These include *infrastructure* considerations such as the supply of electricity and clean water, road network and port facilities extending all the way to the structure of *country's institutions*, such as tertiary education. Similar basic condition for R&D work is the *legal framework* in the country. A basic requirement for the establishment and retention of a company's R&D department in the receiving country is its sufficient technical capability (Beckmann and Fischer 1994).

2.3 Analysis on Influencing Factor Frameworks

Factors influencing industrial R&D on an international scale are numerous and varied but can conveniently be classified into groups that better illustrate their implication (Granstrand, Håkanson and Sjölander 1993). Different approaches have been used to classify motivations for R&D internationalization (Granstrand, Håkanson and Sjölander 1993; Dunning and Narula 1995; OECD 1998; Gassmann and Han 2004). In this chapter, the author presents and describes such prominent classifications presented in table 2. as well as illustrates their purpose in determining the appropriate mode of entry for R&D globalization.

Boddewyn (1985)				
Conditions	Motivations		Precipitating circumstances	
Improved ICT	Centres of excellence	Local advantage	Local manufacturing	Availability of labour
Infrastructure	Availability of labour	Local adaptation	Market access	Local content rules
IP protection	Inward learning	Financial incentives	Peer pressure	New entrants
Granstrand, Håkanson and Sjölander, 1993				
Demand oriented		Supply oriented		
local adaptation		availability of labour		
local requirements		cost advantage		
		centres of excellence		
Beckmann and Fischer, (1994)				
Output-oriented	External drivers	Input-oriented	Efficiency drivers	Political/socio-cultural
Lead users	Tax optimization	Local R&D persone	Synchronous work	Legal requirements
Access to markets	Fincancial incentives	Centres of excellence	Cost advantage	Local content rules
Local collaboration				Technology acceptance
Local brand				Public approval times
Gassmann and Von Zedtwitz, (1998)				
Quality of output	External drivers	Quality of the input	Efficiency-oriented	Political/socio-cultural
Legal conditions	M&A	Improved ICT	Flexible organisation	IP protection
Cost advantages	historic reasons	Availability of labour	Synchronous work	Protectionist barriers
Local advantages	peer pressure	Centres of excellence	cost advantage	Labour relations
Local brand	tax optimization	Local networks	logistic barriers	Local content
Local manufacturing				Subsidies
Local adaptation				
Lead users				
Market access				
Gassman and Han (2004)				
performance-oriented motivation		Input oriented	Business-ecological motivation	
Local adaptation		Availability of labour	Governmental policy	
Cost advantage		Centres of excellence	Market potential	
Financial incentives			Peer pressure	
Market access				
Local manufacturing				
Kummerle (1999)				
Home-base exploiting		Home-base augmenting		
Market access	Local regulations	Availability of labour	Centres of Excellence	
R&D professionals	Local manufacturing	Industry spillover	R&D professionals	
Von Zedtwitz and Gassmann (2002)				
Access to local market			Access to local science and technology	
Market driven	Global R&D		Technology-driven	
Access to market	Centres of excellence	Local requirements	Availability of labour	
Local requirements	Market access		Industry spillover	
Local manufacturing	National treasure		Centres of excellence	
Local adaptation	Home market	Investment constrains	Cost advantage	
	Foreign manufacture	Cost advantage		

Table 2. Table illustrates the different categorizations presented in the literature, the factors associated with them and their relations

2.3.1 *Conditional factors and decision framework*

One such classification approach by Boddewyn (1985) lays out the basic conditions for R&D in any given country in a world as well as describes the decision process from the basic conditions to the underlying motivations all the way to the precipitating circumstances that ignite the spark for R&D globalization. Boddewyn (1985) presents three categories that explain how differing theories of foreign investment can be organized. His framework is based on Aristotle's ideas of condition-motivation-precipitating circumstances. The same framework can be used to organize influencing factors in globalization of R&D when factors are divided into those dealing with conditions, motivations or precipitating circumstances. These can be both internal as well as external factors from the firm's perspective and dwell on the rational, economic viability and structural factors when conducting R&D overseas. Similarly, some of these factors can be macroeconomic while others are microeconomic affecting on individual firm level, when others affect on both micro- and macroeconomic levels.

From the conditions part of the framework three factors are of particular importance:

- Improved information and communication technologies play a significant role enabling viable conditions for global R&D network.
- Improvement in infrastructures necessary for R&D facilities in many newly developed and developing countries through social, economic, and technological development.
- Convergence in international patenting standards and practices offers more uniformed, reliable protection for intellectual property (IP) rights.

Expected benefits from the globalization of R&D are categorized as motivations, which Boddewyn sees as increases in positive organizational outcomes or as decreases in negative organizational outcomes:

- Benefits can be derived with sourcing of top scientific talent, participating in centers of excellence or tapping into a large skill pool that exists in other parts of the world.
- By locating R&D laboratories to different locations globally a varied flow of new ideas, products, and processes can be acquired (Ronstadt 1977; Terpstra 1977).
- Distributing R&D activities internationally allows the capitalization of location-specific advantages by allocating work and/or responsibilities depending on the expertise, knowledge, and external resources of each R&D subsidiary.
- By employing dispersed local R&D facilities local needs related to time, relevance and taste could be better catered (Mansfield et al. 1979; Robinson 1988).
- Government incentives, such as direct R&D grants, tax write-offs, and interest-free loans lure companies to shift their R&D overseas (Robinson 1988).

Situations inside and outside the company that provide motivations for shifting R&D overseas are called precipitating circumstances, which Boddewyn perceives as including the following:

- Wide involvement in overseas production and global marketing often require technical support and local adaptation, which are usually dependent on permanent on-site R&D facilities (De Meyer and Mizushima 1989; Pearce 1989; Mansfield et al. 1979).
- Success of competitors in global R&D may encourage others in the industry to shift R&D overseas as well.
- Shortage of scientists and engineers in many fields in the U.S. (NSF 1990b) and the rest of the Western world (Håkanson and Zander 1988) has been argued to play a part. This shortage of talent has led many companies to look for available talent from their foreign subsidiaries.
- The technological advancement of many non-Western countries in various fields and the increasing number of U.S. patents granted to non-Western MNCs (Glismann and Horn 1988).
- Host governments pressuring MNCs to establish R&D facilities as a condition for market entry (Behrman and Fischer 1980; Robinson 1988).

The importance of Boddewyn's framework is firstly that it clearly lays out the basic conditions for R&D, namely sufficient ICT, viable infrastructure and reliable intellectual property protection and rule of law. Although slightly outdated in regard to many developing or even underdeveloped countries today, in the case that these conditions are fulfilled, the location can be considered as a potential R&D location.

Furthermore Boddewyn's framework presents the decision process and the most important motivations for globalization of R&D. These motivations being: availability of R&D resources such as advanced labor force and cutting edge-technology and science, accessing local proprietary technology or benefiting from technology spill-over, financial incentives and tax deductions, knowledge acquisition through inward learning. Although Boddewyn (1985) do not mention the importance of market size and growth as a motivation, he nevertheless lists local adaptation of products that fit the host market as an important motivation and market size as a precipitating circumstance.

The last part of the framework explains the decision to take action regarding geographical globalization of R&D activities. Albeit companies might have sufficient motivations for R&D globalization or more than one motivations, Boddewyn (1985) presents, how it takes a change in either the operational, competitive, legal environment or supply of advanced R&D resources to commence R&D globalization in a company. Despite that his framework does not touch upon the mode of R&D globalization, the author sees it as the thought experiment on whether a company should consider R&D globalization.

2.3.2 Firm specific capabilities in home or foreign market

For his part, Kuemmerle (1999) divided reasons for globalization of R&D into two categories of R&D globalization: home-base-exploiting (HBE) and home-base-augmenting (HBA). This framework's purpose is to help managers to structure their planning processes and better utilize the advantages present. He saw firms as entities seeking to exploit specific capabilities present in their organization in a foreign environment or building new firm-specific advantages from resources present in the foreign environment.

Reasons for home-base-exploiting (HBE) R&D operations were listed as follows: attractiveness of the target country's market, share of population with tertiary education, regulatory reasons and manufacturing or marketing reason (Kuemmerle 1998). He nevertheless point out that, according to his research, companies will establish their international sales and manufacturing presence before investing in HBE R&D sites abroad. When interpreting the reasons, it also became evident that the share of population with tertiary education might be applicable to both HBA and HBE investment.

According to him, causes for home-base-augmenting (HBA) R&D operations are: private and public investment to R&D and the spill over gains from that investment, one country's stock of knowledge and the centers of excellence this knowledge base and the national science structure generates. A proxy for this measurement was the level of scientific achievement in the country. The quality of the human resource pool and thus the availability of talented labor was also identified as a reason for HBA R&D.

The basic idea behind Kuemmerle's concept is that, after the decision for R&D globalization is seen as beneficial to a company, the firm has to determine, whether it wants to continue catering to its home market, utilizing resources available in the offshore location by thus furthering its competitive position and introducing new products, or whether it wants to access the host market by capitalizing on the existing capabilities at home. Be that as it may, Kuemmerle (1998) talks about the own capabilities of a company, whether they are those already present in the home market or those that are going to be acquired from the host market. Thus he provides the basic distinction between offshoring R&D and the internationalization process that guides the firm to a new market, but decisively leaves out offshore outsourcing of R&D.

2.3.3 Role of macroeconomic factors

Another classification approach differentiates between demand-oriented and supply-oriented drivers for R&D internationalization (Granstrand, Håkanson and Sjölander 1993). It can be conceived as a more detailed distinction between the watershed drawn by Kuemmerle (1998) that also takes into account the micro- and macroeconomic distribution. The classification proposed by Granstrand, Håkanson and Sjölander (1993)

illustrates the different factors in a more concrete way and takes into consideration the scenario for offshore outsourcing, when neither labor nor science nor markets are determining factors in R&D globalization to the host country.

The demand-oriented factors induce companies to locate R&D abroad in order to better serve foreign host markets (Granstrand, Håkanson and Sjölander 1993). Such factors according to Granstrand, Håkanson and Sjölander (1993) are special needs of the local country/market, which require modifications of the firm's products i.e. local adaptation and host country restrictions, such as local content requirements, tolls, import quotas, and fulfillment of standards.

The supply-oriented factors in the other hand are those dependent on the host market characteristics. These factors thus illustrate many of the local advantages, such as favorable access to skilled technical expertise i.e. availability of labor, which can be available perhaps at a lower cost than elsewhere, a factor that also has been already reported in literature as cross country cost differentials. Similarly, as a factor they point to the access to sophisticated foreign scientific infrastructure (e.g., new regional technological competence centers such as universities and other research establishments) i.e. centers of excellence.

Granstrand et al. (1992) in an older study have mentioned another related group of motivations, which are the environmental motivation factors. They say that the notion of "national systems of innovation" can foster a suitable environment for R&D, which is supported by views on that national institutional structures, policy environments, industrial organizations, traditions, etc. can impact economic performance.

Nevertheless, Granstrand, Håkanson and Sjölander (1993) indicate that the establishment of foreign manufacturing subsidiaries often happen, first through exports then later through a sales subsidiary. Manufacturing then forces companies to enact technical support activities, which tend to evolve over time into proper development projects (Granstrand, Håkanson and Sjölander 1993). Thus they show how company's operations evolve once it has attained a certain position in the local market and then the inducements to set up local adaptive R&D become pressing, highlighting the case for market dependent R&D internationalization. What their classification shows us, is that factors have an influence either on macro or micro level, while some function on both levels. This segregation between macro and micro levels presents some factors as more environmental than motivational. They also provide a clearer distinction between factors that favor home market augmenting through supply driven offshoring and the ones that speak on the behalf of demand driven home-country exploiting through internationalization.

2.3.4 *External, efficiency and socio-cultural drivers in global competition*

Beckmann and Fischer (1994) present a more refined classification scheme, where they identified five categories of R&D globalization drivers: input-oriented, output-oriented, external, efficiency-oriented and political/social-cultural. This classification is based on the work by Granstrand, Håkanson and Sjölander (1993), as the underlining idea for the input-oriented and output-oriented categories correspond with their supply- and demand-oriented view of. The three other categories presented by Beckmann and Fischer (1994), which are external, efficiency-oriented and political/socio-cultural factors, further illustrate the case on differing motivations for R&D globalization. From their work can also be distinguished some conditional factors, similar to those reported by Boddewyn (1985), which are technical development and infrastructure constrains. These factors, even though divided to input-oriented or efficiency-oriented by Beckmann and Fischer (1994), differ from the others in their category and have properties corresponding to conditional factors. Thusly Beckmann and Fischer (1994) present five principal classes of drivers for R&D entry into host country.

The first class encompasses drivers related to personnel, know-how and infrastructure. Input-oriented factors consist of availability of labor, centers of excellence, local presence and the conditionality of sufficient infrastructure. Availability of labor, which is a factor of first and foremost importance for the success of the R&D mission, is amplified by a scarcity of engineers and researchers in the West. Difficulty of attracting advanced labor overseas guides companies to centers of excellence, such as public institutions, research centers and universities as well as private facilities. These centers of excellence form local pockets of innovation and provide knowhow and infrastructure. Local presence and a recognizable brand increase company's attractiveness as an employer and facilitate operations in the target country.

According to Beckmann and Fischer (1994), output drivers are product-oriented factors, which include the following: local lead users, proximity and access to markets, inward learning, supplier and distributor collaborations and brand or local image of the company. Market potential i.e. market size and growth is especially paramount in regards to company's interest in placing R&D to a specific country and spending resources for the required product adaptation. Thus their study suggests that in order to be competitive, products have to correspond to market and even individual customer needs and requirements, especially when introducing a novelty product to the market. The scale of required modifications depends on the variability of customer needs and the amount of product adaptation needed to modify the existing product into meeting local market needs is an output driver (Beckmann and Fischer 1994).

External factors are government incentives or subventions such as overall tax optimization schemes, grants, subsidies and other financial incentives available in the host country. R&D locations can be highly dependent on the overall tax optimization of a

concern. Locally produced R&D may also entitle the company for price incentives. From the public perspective, external factors are clearly macro economical tools, but financial incentives such as pure cash can be a major factor influencing decision on the micro level especially in small companies. This classification to such external drivers is a fresh look, not covered by Granstrand, Håkanson and Sjölander (1993) although presented by Boddewyn (1985), another shared similarity on par with the conditional factors discussed. In later work Gassmann and von Zedtwitz (1998) also report these external factors as part of their classification.

Efficiency drivers, for instance the potential to build a global 24-hour laboratory, coordination costs and critical laboratory size, play a role as well. Other efficiency drivers for example are direct cost advantages extensively discussed in academic literature, such as but not limited to the labor costs. (Beckmann and Fischer 1994) However, previous studies have demonstrated that direct cost advantages rarely have an influence. However, in these same studies other cost considerations, such as coordination and transfer as well as critical laboratory size. Beckmann and Fischer (1994) state nevertheless that acquiring sufficient critical mass in laboratory size can be dependent on direct cost advantages. More specifically, R&D unit size has been anticipated on an industry dependent way to have an effect on the R&D globalization. Low personnel amount combined with restricted resources and standardized costs can create a suboptimal technical and financial workload. Depending on the facility size, regards to resources and personnel, a detrimental over optimal situation can also be created. Cost of coordination is a centralization force and negative to any attempt in decentralizing these higher value operations, without the huge development in information and communication technology (ICT). If the unit's size and functions expand, the communication and coordination together with administrative costs become overly proportional to the R&D function, which leads to loss of customer focus and flexibility. (Beckmann and Fischer 1994)

Political and socio-cultural drivers also seem to have a considerable impact in locating R&D abroad, such factors include: legal requirements, local content rules, technology acceptance and public approval. Legal requirements contain safety measures, standards and other permits from local institutions. When product's applicability to local requirements and standards has to be verified, the legal or socio-cultural framework is very important, as the process takes a long time and requires wide open disclosure and cooperation with stakeholders. Furthermore, according to Beckmann and Fischer (1994) these requirements can be a source of substantial costs. Sometimes product can even be subject to local development or production requirements. Local content requirement puts pressure on companies to shift their R&D, either as a government requirement or due to encouragement from subsidies and free import duties. In typical agreements the amount of locally produced value is required to be increased annually. In extreme cases, local content requirement may mean government ownership. Beckmann and Fischer (1994) note that socio-cultural values, differences and requirements as well as country's

development and economic conditions may also provide requirements for product adaptation. The local acceptance of a technology or research field as well as the public image of a company is important to the continuation of operations in a certain country. Furthermore, funding for research in public institutions is dependent on general opinion.

Beckmann and Fischer (1994) show how external, efficiency and socio-cultural drivers can become the most important factors even though company's underlying motivations would be in line with either the input-driven or output-driven factors. This is especially true in cases where infrastructure or legal considerations prevent any longer term involvement in the country even when market, labor or technology motivations would exist. Furthermore the external, efficiency and socio-cultural drivers can be the only factors that are of interest, when neither market nor advanced R&D resources considerations are present and when the only motivations are cost considerations, financial incentives, legal requirements or political considerations such as trade barriers. These cases thus illustrate the legitimacy for offshore outsourcing of R&D in relation to R&D offshoring and internationalization of R&D.

2.3.5 Legal market requirements and stature of cost considerations

Following the above classification scheme used by Beckmann and Fischer (1994), Gassmann and von Zedtwitz (1998) divided factors affecting globalization of R&D emerging from their own study, into five corresponding categories: quality of the input at the foreign site, quality of expected output, external drivers on R&D globalization and factors dealing with the general operating efficiency as well as political and socio-cultural issues.

Among the input-oriented factors they list: improvement in information and communication networks, insufficient home personnel, prevalence of local pocket-of-innovation, local infrastructure suitability, amount of qualified personnel abroad, accessing local scientific community and tapping into informal networks (Gassmann and von Zedtwitz 1998).

Similarly, they have grouped factors into output-oriented category: national and legal conditions, country-specific cost advantages, local economic and natural advantages, improvement of local image, adaptation to local production processes, customer-specific development, closeness to lead users, local values as well as market and customer proximity (Gassmann and von Zedtwitz 1998).

Concerning the external drivers for R&D internationalization, Gassmann and von Zedtwitz (1998) list acquisition of parent company or a merger, historic reasons, peer pressure, tax optimization. Their efficiency-oriented factors are those from management literature: improving flexibility through new organization, mass depression in home country and reduction of development failure risk. In addition, efficiency-oriented fac-

tors include also those from rational economic: local critical mass, making use of many time zones, lower R&D personnel costs and reduction of development cycle times. Furthermore their efficiency-oriented factors include those from logistic theories, such as: closeness to production, marketing, distribution and overcoming logistic barriers.

In the other hand, political socio-cultural factors are those that have to do with international relations, political situation and trade regulations: improvement of international patenting laws, overcoming protectionist barriers, local social and peaceful labor relations, local content, home country legal restrictions, low acceptance and subsidies.

Gassmann and von Zedtwitz (1998) noted that direct cost advantages, such as labor costs rarely influence the internationalization of R&D as suggested in their later work and other academic literature, although controversially discuss cost in many context and present cost considerations. Since they nevertheless list this as both an efficiency-oriented and an output-oriented R&D globalization factor derived from their research and interviews, its significance has to be evident in some cases of R&D globalization.

What Gassmann and von Zedtwitz (1998) discovered concerning internationalization of R&D, is that in some industries national and legal requirements can be as important as market considerations. Alas, they also brought into discussion the historical perspective of a company's involvement in international business as well as the potential effect of mergers and acquisitions along with customs and trade barriers. Furthermore, they based direct and consequential cost considerations as both an efficiency-oriented and an output-oriented R&D globalization factor indicating that on top of R&D offshoring and R&D offshore outsourcing, cost factor plays a part also in internationalization of R&D.

2.3.6 Inherent difference of research and development

Research activities have been shown to have distinguishable different characteristics than development activities (Abetti 1985; Allen 1980; Cleland and King 1983; Cleland and Kocaoglu 1981; Cooper 1983; Tornatzky 1983; Twiss 1980; Withey et al. 1983). The inherent differences of research and development can be erroneously disregarded with the usage of the term R&D. The necessities of science entail different managerial problems than those of engineering and development (von Zedtwitz and Gassmann 2002, 571). Research has been described as technology expansion, usually noted to concern the expansion of scientific knowledge and assessment of its feasibility (Leifer and Triscari 1987). Thus technology expansion through research has to do with the inventive process and the expansion of technology base (Leifer and Triscari 1987). Development contrary has to do with the intent on creation of a new or modified product, process or service through the application of technology base to its operational requirements (Leifer and Triscari 1987). A generally understood relationship of the R&D tasks

is that development is more structured and less varied, whereas research is theoretically oriented and widely varied (Leifer and Triscari 1987).

The objective of research is thus the generation or expansion of knowledge, concept testing, creation of prototypes, new component testing, etc. (Leifer and Triscari 1987). It is suggested that research or technology expansion process is a set of uncertain and unpredictable activities taken to reduce technological uncertainty, which tend to proceed in an unpredicted non-planned series of phases (Leifer and Triscari 1987).

The aim of development is geared towards the physical output of new products or processes (Allen 1980; Johne 1984). Satisfying operational or customer needs and fulfilling cost and scheduling constraints are generally considered as the objectives of the development process (Leifer and Triscari 1987). Development process is usually a less uncertain, more controlled and focused phase aiming for a compromise of the needs of the different organizational players and desired objectives (Leifer and Triscari 1987).

Descriptions attached to research and development on the counts of technology requirements and task complexity is that technology associated with research is more non-routine than the technology needed for development on a technology requirement continuum from nonroutine to routine (Perrow 1967; Van de Ven and Delbecq 1976). Products utilizing a significant new technology require technological research input prior to product development, and although closely intertwined these processes typically require technology transfer between them (Eldred and McGrath 1997a,b).

As R&D work progresses to being an operational reality that is near production approval, internal and external special interest groups become more involved and funds are required. At this point, external influence on the R&D project grows and the project requires more maintainability from higher management. Focusing on the distinction between R and D, Leifer and Triscari (1987) therefore argue that development is synonymous with higher amounts of environmental uncertainty compared to research (Leifer and Triscari 1987). This result is directly in contradiction with their findings on increased communication requirements for research.

Another watershed between R and D has to do with interdependency of the project, as in the extent to how the project is interrelated to other parts of the organization to make its contribution (Leifer and Triscari 1987). Development projects are seen as requiring more coordination, approval and input from other functional parts of the organization (Leifer and Triscari 1987). This would suggest that on development projects, due to higher risks, organizational interrelatedness and lesser knowledge sharing, there is a need for more centralization and formalization in the form of location requirements, control and management participation than what is associated with research projects.

Leifer's and Triscari's (1987) work reveals that, when analyzing R&D, it is paramount that research activities are scrutinized independently as research. Identically development should be considered independent from other similar activities. Iansiti (1993) goes even further by showing that different research tasks may vary greatly in their con-

text, requirements and contributions. An example of this is the inherent difference of basic research from applied research (Lall 1979). Where the former attempts to explain a novelty concept, finding or a theory, the later is geared towards the refinement of the former or its applications (Lall 1979). Equivalently Iansiti (1993) explains the continuum of different development activities and how those requirements presented for instance by Leifer and Triscari (1987), can differ for distinct research tasks. Thus we should also take into account that dissimilar research tasks or dissimilar development tasks can differ in nature as much as development varies from research (Iansiti 1993).

2.3.7 Market and technology in regards to company size and structure of R&D

As described above the term R&D is not homogenous and, as fundamental differences exist for research compared to development (Leifer and Triscari 1987), they are also subject to different location drivers. Von Zedtwitz and Gassmann (2002) provided empirical evidence for separation compared to integration of the R&D function. Von Zedtwitz and Gassmann (2002) determine access to local markets and customers as well as access to local science and technology as being the principal factors behind locating R&D globally. In the light of these two factors, they describe four different trends, which aim to capture locations specific advantages separately to both research as well as development. Thusly, depending on whether research or development is concentrated domestically or decentralized over different countries, they propose four generic research and development globalization types: “national treasure”, “market driven”, “technology driven” and “global”.

When both research and development is concentrated domestically at company's home base, this organization of R&D is titled “national treasure” model and is based on capitalizing on efficiency advantages of centralization. The model is characterized by little internationally dispersed R&D, focus on domestic market, a dominant position in design or technology with company's products requiring very little adaptation to foreign markets. Thus core R&D function is kept where it is easiest to control. Another important feature of R&D retention in home country is the ease of achieving minimum critical mass, which is the minimum amount of money or number of people required to start or sustain an operation or business process (Patel & Pavitt, 1992). In this model foreign manufacturing sites and sales organizations are still an important source of information on new market needs and customer satisfaction (von Zedtwitz and Gassmann, 2002).

When, in the other hand, research is more globally dispersed than development activities, with a deficiency of scientific personnel and talent in the home country as well as necessity of access to foreign centers of excellence, the preferential archetype conveyed by von Zedtwitz and Gassmann (2002) is the technology-driven model. Research thus

attempts to leverage industry spillover, location and market as well as academic competencies that are available in the chosen region. While development is retained centralized by the scale effects from establishment of technology platforms and from the availability of unique specialized testing equipment, synergy effects from ease of communication or knowledge sharing (Buckley and Casson 1976; Leifer and Triscari 1987), as well as due to efficiency and cost advantages, tendency for strong managerial oversight and central control as reported by Leifer and Triscari (1987) and nursing of commercially valuable assets. Leifer and Triscari (1987) indicate that these effects tend to be less associated with research and thus the location specific advantages possibly outweigh the centralization forces.

Market driven model emphasizes domestic research but advocates dispersed development. Companies chiefly following the call of the market, are focusing on business development, which is centered on customer demands and not led by scientific exploration (von Zedtwitz and Gassmann 2002). According to von Zedtwitz and Gassmann (2002), critical mass for research is attained with smaller contributions by keeping it home as it is of low significance and the benefits of internal research are constantly put into question. The focus is on product development and new business creation with regional market requirements such as codes, standards and customer behavior crucial. Highest level of R&D responsible for breakthrough innovations is kept in home location, manufacturing R&D responsible for incremental improvements is dispersed according to manufacturing sites and field engineering, chiefly associated with local adaptation and fulfilment of customer requirements, is handled independently from each market area (von Zedtwitz and Gassmann 2002).

The fourth trend conveyed by von Zedtwitz and Gassmann (2002) is titled global R&D and has to do with dispersed research and dispersed development. The cornerstone of R&D strategy for these companies is the global coordination or R&D through integrated R&D networks. Availability of high-quality scientific input such as centers of excellence is the dominant location decision criteria for research and development is market driven and conforms to local demands, standards and codes. The strategy is for the added significantly higher cost of management of R&D of global research to be offset by greater innovation. The advantage is that knowledge is readily transferred both ways and cross-functionally (citation) thus locally developed science can be utilized or adapted quickly worldwide and single development centers may take responsibility of the global launch of a product.

The four different trends explained by von Zedtwitz and Gassmann (2002) illustrate how companies engaged in development have different interests and requirements than companies engaged in research. Furthermore by categorizing companies to either market seeking firms that are in the process of internationalizing their R&D operations or into technology, science and R&D resources seeking firms who are offshoring their R&D efforts to a more suitable operational environment. Von Zedtwitz and Gassmann

(2002) formulate the governance form (Boehe 2008) for companies engaging either in offshoring of research or in the internationalization of R&D. Besides, the national treasure model shows how the minimal amount of geographically dispersed R&D can be bolstered with R&D offshore outsourcing that is centered on decreasing cost or gaining specific capabilities from outside the company. When looking as a continuum and taken into their extremes, these four trends can also distinguish between different company sizes, from privately owned family companies seeking to expand all the way to MNCs.

2.3.8 R&D globalization in the context of Peoples Republic of China

In another classification by Gassmann and Han (2004), again based on the framework of Beckmann and Fischer (1994), but not exclusively conforming to their scheme, they present classification within the Chinese context. In this classification they merged output and efficiency-oriented motivation factors into performance-oriented motivation factors while combining the external and political/social-cultural into business-ecological motivation factors (Gassmann and Han 2004).

According to this classification, the performance-oriented motivation factors consist of three factors. The first factor they point is comprehensively covered in literature as local adaptation or product adaptation to markets. This type of customer and market-specific development lures companies into establishing R&D operations to host markets, where products are locally develop specifically for that market. Based on the interviews they have conducted, adapting products to the host market is widely seen as basic necessity. Secondly, they cite cost advantages as a factor, as the cost of equal size R&D facilities in China is roughly only one tenth of that in the West (Li and Zhong 2003). Further they have divided cost advantages firstly into cross-country cost differentials, as lower wages attract R&D, secondly adapting over-engineered product to Chinese customer's lesser requirements. Besides, it's related to preferential policies or financial incentives enacted to encourage establishment of foreign R&D, such as corporate tax exemption or duty free importation of R&D equipment. Short R&D cycle time and adaptation to local manufacturing processes are clear benefits of localized manufacturing R&D. Local manufacturing R&D can also assist in improving the quality, offerings, reduce costs, or increase capabilities of the manufacturing operation (Ambrecht 2002).

Amongst the input-oriented motivations, the huge potential human resources are of great importance for establishing R&D in China. Thus input oriented motivations include the availability of qualified personnel: firstly those educated in Chinese Universities and secondly the highly skilled overseas Chinese students returning to China. These returning Chinese form a uniquely qualified additional human resources pool, which bring experience and knowledge from around the globe. Another side of the input oriented factors are the benefits that can be gained from informal networks and tapping

local information sources. Gassmann and Han (2004) also list the High Technology Development Zones (HTDZ), which host a large number of universities and scientific institutions as well as start-up firms, foreign-capital firms and large-scale local firms as an important input factor. These HTDZs are another factor that has already been reported in the literature and previously has been described as centers of excellence.

Business-ecological motivation factors, which combine those described as external and political/social-cultural factors, have to do with the macroeconomic conditions, trends and policies of the host country. Governmental policy is the first reported factor in this category, which is nevertheless related to two other factors that are availability of labor and financial incentives. These governmental policies help to attract highly educated returning Chinese students and professionals back from overseas and provide financial motivations for R&D investment (von Zedtwitz 2004). Another factor is the continuing economic growth and the overwhelming market size, which has strategic importance (Gassmann and Han 2004). Another macro economical factor they list is the possible mid- and long-term competitive advantages of the market, which great lots of peer pressure inside an industry. Together these two factors make up the reported market dependent justification for the added costs of internationalization of R&D in hopes of future market gains.

What the classification by Gassman and Han (2004) offers, is the relevance of majority of factors in the Chinese context, the magnitude of these factors along with the unique ascendancy of the Chinese government. Engineering man-hour costs in China are only one tenth of that in the triad region (Li and Zhong 2003). In 2002, 2.5 million students graduated from the country's 3000 universities and colleges including 66,000 M.A.'s and 14,000 PhD's, ranking third; USA (40,000) and Germany (30,000) (MOE PRC 2003a). In addition to the domestic graduates, more than 580,000 Chinese students studied abroad between 1978 and 2002, with 150,000 returning (MOE PRC 2003b). Chinese policy makers attract R&D to special economic High Technology Development Zones (HTDZ), which have resulted in 276 international R&D alliances between 1995 and 2000, along with lion's share of global FDI in 2012 (18%) 253 billion USD. Given the power of Chinese government, they pursue 'technology for market' policy, playing MNC's against another, thus to accelerating investment on R&D.

2.4 Field of Study

2.4.1 *The new paradigm of innovation and higher value activities in China*

Historically Western companies have seen China as an industrial base and brought technologies to China only for the purposes of implementing them in local manufacturing joint ventures. Recently as a part of the new paradigm companies have started to view China as a potential destination for research and development. Kuemmerle (1999) points that it seems likely that populous Asian countries, such as India and China will increasingly attract HBE-type facilities. In addition to the large market these countries possess, they are also a home to a number of elite institutions of technical and scientific learning, which preselect the top qualified human resources, providing to multinational firms an easy access to advanced labor and top talent (Kuemmerle 1999).

To endorse the new paradigm, China has risen to rank as the third most R&D intensive country in the world, according to a (2003) OECD report. In 2001 total R&D spending by USA totalled US\$282 billion, while that from Japan was US\$104 billion, while China's R&D spending reached nearly US\$60 billion, third behind US and Japan, but ahead of Germany's US\$56 billion. Similarly in 2011, China surpassed United States and Japan by becoming the world's top patent filer, with its continued drive for innovation and improvement on its track record of intellectual property rights. As stated by a Thomson Reuters report, published patent applications from China are on track to total nearly 500,000 in 2015, a considerably more than the close to 400,000 from the United States or that of Japan amounting close to 300,000 (Thomson Reuters 2011). Data from Thomson Reuters Derwent World Patents Index shows that there is an 16.7 percent average annual increase in China's patent office's published patent applications, which have risen from 171,000 in 2006 to nearly 314,000 in 2010, (Thomson Reuters, patents 2011).

In his 2004 article von Zedtwitz identified 199 distinct foreign R&D centres established or being formed in China in early 2004, almost a quarter of the foreign R&D laboratories in USA. This has happened according to von Zedtwitz (2004) in a relative short period of time and during a time of global economic uncertainty and decreased R&D spending. Taking into consideration the huge numbers of college graduates and the continued demand by foreign companies it is expected that this development will continue as depicted by Gassman and Han (2004).

Von Zedtwitz (2004) also reports on the locations of foreign R&D labs in China, with an overwhelming majority, 89% of all foreign R&D laboratories, are concentrated along a relative short strip of land between Beijing and Shanghai. He further reports that American companies tend to be located in Beijing while European firms go to Shanghai. Gassman and Han (2004) tell how Schindler in the late nineties established an R&D centre in Shanghai based on its market's sophistication and growth, a reputation that

Shanghai continues to enjoy among technology intensive companies. Beijing also tends to be the preferred R&D site for companies in the telecommunications and electronics industry, while Shanghai host mainly food, pharmaceutical and engineering companies. (von Zedtwitz 2004). Industry white papers also note that Shanghai has a strong medical science tradition and is today the centre of one of China's most powerful clusters of medical research players. Numerous international pharmaceutical groups and well-reputed universities operate out of Shanghai.

2.4.2 Globalization of pharmaceutical R&D: the industry and China

Differences among industries are significant for R&D globalization (Macher and Mowery 2008). The normal supply and demand market environment for pharmaceuticals along with healthcare marketplace is distorted due to their intrinsic characteristics (Depret and Hamdouch 2000; Hamdouch and Depret 2001). The interests of pharmaceutical companies, public, patients and the healthcare system due frequently overlap but not always. This is reflected in the conflict between a continuous need for new vaccinations and medicines against increased regulatory control, price bargaining pressure from governmental healthcare institutions, greater amount of alternatives in drugs and/or treatment options, while the complexity and thus risks of modern drug molecules are substantially greater (Hamdouch and He 2009).

Pharmaceutical industry has continuously shown high-levels of open innovation with distant partners (OECD, 2008). High R&D investment intensity on pharmaceutical sector is seem to be closely linked to its competitive advantage which nevertheless is dependent on more systematic and dynamic factors (Hamdouch and He 2009). Nevertheless, severe financial problems can arise when annual R&D cost considerably exceeds the yearly cash flow or a company has R&D intensity equivalent to 10% of turnover. In many research intensive sectors technological development has lead to a "R&D arms race" (von Braun 1995). The research-intensive pharmaceutical firms are an rare exceptions to this as their shareholders see long term investment as industry characteristic and expect high values from extremely high R&D investment ratios (Gerybadze and Reger 1999). This market truce has been shaken right along with the declining returns of investment in the pharma sector (Paul et al. 2010).

Productivity in pharmaceutical R&D has been declining for an extended period of time and many complex reasons has been attributed as its cause (Paul et al. 2010). The trend does not seem to subside as more than US\$209 billion in annual drug sales at risk due to key patent expirations in 2010-2014. The patent expirations are estimated to result in \$113 billion of sales being lost to generic substitution (Paul et al. 2010). Causes for increased costs in the pharmaceutical industry can be divided into external causes, such as growing regulatory conservatism and lack of international regulatory harmoni-

sation, and internal causes of R&D, such as lack of managerial oversight on cost-containment and a culture of suboptimal use of resources (Ruffolo 2006). The pharmaceutical industry is one of the most regulated industries in the world, and this is the source of external causes for decline in R&D productivity. The quality standard upheld from the pharmaceutical industry continues to increase, with questionable benefit to public safety or patient health with clear relations to government.

Cheap labor has been the main drivers of manufacturing in China. Now that the Chinese wage costs are rising sharply, the yuan currency is gaining against the U.S. dollar, and transport costs are increasing, the advantages traditionally associated with PRC against the U.S. and other traditional countries for conducting R&D have narrowed a bit in recent years (Thomson Reuters, manufacturing 2011). The Fiscal consolidation on the pharmaceutical industry reported by von Braun (1995), Gerybadze and Reger (1999) and Paul et al. (2010) requires a stable cost situation, without wage increases.

Alas, the Chinese government as well as local or regional governments have recently been offsetting these rising costs by providing generous subsidies for the establishment of foreign R&D activities, thus renewing partly the cost advantage's for doing R&D in China. These incentives include grants given to foreign R&D centres in China that can import certain equipment duty free. Chinese government and more clearly the local municipal governments attract R&D investment by providing advanced R&D infrastructure, together with space, high-tech facilities and financial incentives (Gassman and Han 2004). Such financial incentives include up to three year tax levies for the establishment of a R&D centre. This is supplemented with a 50% tax discount for additional three years from the third year onwards. The incentive can further be continued from the seventh year onwards with a 15% discount, along with other tax incentives (Gassman and Han 2004). Direct government subsidies, price incentives and tax exemptions play a major role in the pharmaceutical industry (Beckmann and Fischer 1994). This case is highlighted in China with its Twelfth Five-Year Guideline that is centred on China's push for more technology intensive sectors that includes a special mention on pharmaceuticals and biotechnology (Xinhua 2010; KPMG China 2011).

2.5 Pharmaceutical Drug Discovery

Pharmaceutical product development pipeline covers the overwhelming majority of pharmaceutical industry's research and development spending and activities. The development pipeline is a generic reference to the different parts of pharmaceutical drug discovery process. The purpose of *drug discovery* is to advance a product candidate through progressively later stages of R&D to clinical phases and eventually commercialization (Moos 2001). Its ultimate goal is the development of novel or improved high quality pharmaceutical products in a cost-effectively, with a continued support for prod-

ucts throughout their life cycle (Gad 2005, 1). The process is fairly vested due to regulations, quality control issues (Gad 2005, 337, 343, 346), tradition and tendency for best recognized procedures (Gad 2005, 560). Its different parts are in general as depicted in figure 2: predisccovery, discovery, pharmaceutical formulation and analysis, scale-up and process development, pre-clinical trials and toxicology as well as early- and late stage clinical trials (Gad 2005, 2).

2.5.1 *Predisccovery*

The *predisccovery* stage has all to do with understanding the true pathogenesis of the disease as before any discovery for potential new medicine can be done the underlying causes of the condition has to be unraveled (Gad 2005, 22; Cayen 2010, 8). In modern predisccovery stage this has to do with understanding how the genes that encode proteins are altered if applicable, how that or other factors alone or together with a genetic alteration affects the proteins they encode, how those proteins interact with each other in living cells, how those cells affect the tissue they comprise and finally, which physiological conditions result to the patient from the affected tissue (Matsoukas and Mavroumoustakos 2002, V, 229, 236, 241, 251, 258, 267, 272, 279, 294). Thus the genetic, proteomic, cytological, histological and anatomical knowledge derived from the patient forms the basis of finding a new treatment (Cayen 2010, 3, 5). After sufficient understanding of the underlying causes of the disease is established the predisccovery stage continues with target identification and target validation.

Target identification requires selection of a target molecule for a potential medicine from the chemical cascade of molecular interactions involved in the disease, i.e. choosing a biochemical mechanism involved in a disease condition (Gad 2005, 15, 33; Cayen 2010, 8). A critical feature for the molecule from a chemical pathway involved in the disease that is selected as a target for a medicine is that it has to potentially interact with and be affected by a drug molecule (Gad 2005, 33–34; Cayen 2010, 5, 8). This is either by making the molecule more active or less active, or changing its activity all together in the chemical cascade (Cayen 2010, 5, 8). Generally a target is a single molecule, such as a gene or protein, incrementally involved in a particular disease (Cayen 2010, 8–9; Vallance and Levick 2007). Target molecule is often responsible either for a molecular imbalance by causing an important protein from being produced, by leading to overproduction of proteins or has altered function due to erroneous protein splicing or folding. The purpose of *target validation* is to conform that the target molecule is actually involved in the disease and that its function can be affected with a drug molecule whose pharmacokinetic properties and bioavailability are sufficient (Gad 2005, 3, 34). The target's relevance in the disease is studied through utilization of the disease's animal models and experiments in living cells (Gad 2005, 3). Target identification is governed

by the early project portfolio management that attempts to strike a balance between the requirements of the disease, the potential to turn the target into a medicine compound and business considerations (Gad 2005, 3, 47). Target identification has seen a steady increase in importance (Shayne 2005, 1).

The underlying hypotheses of the pre-discovery stage on toxicology and clinical effectiveness form the basis for the future success of the resulting clinical trials and drug launch and is thus extremely important that the best scientific knowledge in the world is behind any decisions to pursue drug discovery on certain type of disease or its certain affecting cause (Gad 2005, 2–3). All drugs on the market today are estimated to target only 500 biomolecules, and although major pharmaceutical companies change their target portfolio they still all focus on the same major classes of targets (Bleicher et al. 2003). With all the companies focusing on a limited number of targets (Gad 2005, 14; Harvey 2001) there is a competition for brainpower in the form of best scientific minds and experts on these household targets (Lewin, et al. 2009). Furthermore the number of highly advanced centers of excellence is particularly limited in the pharmaceutical industry (Kuemmerle 1999). Thus pre-discovery stage R&D can be seen as dependent on centers of excellence and a global network of R&D cooperation with renowned specialist. These specialists and the centers of excellence are usually dependant on public financing, thus their focus and research in general is shaped by the national innovation system in the country. Reception of a grant is a recognition of the importance of the research and the researchers but also a way to shape direction of the research (Benner and Sandström, 2000). Successful research organizations in the academic field are those groups which can attract funding, prestige and recognition (Benner and Sandström, 2000). Thus the influencing factors most strongly associated with pre-discovery are the effect of national innovation systems, centers of excellence and financial incentives such as research grants.

2.5.2 *Discovery*

The next stage of drug development is *discovery* (Gad 2005, 1). Its objective is to find a promising molecule, called a lead compound that may act on the target and thus alter the course of the disease (Gad 2005, 3, 12, 22). Until recently, majority of the lead compounds were found in nature from sources such as bacteria in soil, mold and plants (Gad 2005, 12, 14, 560). Although nature still provides useful substances (Newmann et al. 2000) thanks to scientific advances molecules can now be synthesized *de novo* from elements and computer modeling can be used to predict the different reactions of the molecule. High-throughput screening is the most utilized way in finding lead compounds (Gad 2005, 560). Through robotics and advanced computing it allows testing of hundreds of thousands of molecules with suitable properties, called hit-molecules (Gad

2005, 50–52), against the target molecule to yield a number of lead molecules that would have pharmaceutical potential (Gad 2005, 560).

The first part of discovery stage is *hit-to-lead* where molecules or libraries of molecules are selected for high-throughput screening because they possess properties needed in a new drug or have properties already found in a known drug molecule (Gad 2005, 560–561,). To yield a lead compound these hit-molecules are tested against the target to select those with a confirmable effect on the target molecule (Gad 2005, 33–34, 36). Compounds selected from the hit-to-lead part go through early safety tests in *lead discovery* that provide an initial assessment of the absorption, distribution, metabolism, excretion and toxicological properties of the lead compound (Gad 2005, 458–459).

In *lead prioritization* part of discovery the properties of various lead compounds are compared in order to select a lead compound or lead compounds with the greatest potential to be developed into effective and safe medicines (Gad 2005, 43, 45). This is often combined with the *lead optimization* part where the lead compounds selected from the initial screening are altered by changing their structure for the purpose of making them more effective and safe (Gad 2005, 47, 459). Making and testing hundreds of different variations called analogues of each original selected lead compound achieves this (Gad 2005, 44, 53–54). Already at this early stage the lead compounds will be considered through the nature of its formula and the inactive ingredients needed, its delivery mechanism as well as its potential for large-scale manufacturing in conjunction with its effectiveness and safety resulting in an active pharmaceutical ingredient (API) (Gad 2005, 55).

The discovery stage has seen a massive growth in screening compound numbers in past 15–20 years with a corresponding increase in costs without any increase in successfully launched new medicines (Bleicher et al. 2003). The early discovery phase is the most labor intensive part of drug discovery, with fairly standardized procedures (Paul et al. 2010) and thus a good target for offshoring R&D due to savings on labor cost and availability of large R&D labor pool if stringent quality requirements can be met. The influencing factors that play the greatest part in discovery are: cross-country cost differentials and availability of labor, although with some basic infrastructure requirements.

2.5.3 *Preclinical*

Preclinical stage is preceded by characterization of the molecule, pharmaceutical formulation and process development (Gad 2005, 458). Each of the selected APIs or drug candidates is then extensively characterized to determine the molecule's shape, size, stability, strengths and weaknesses (Gad 2005, 48–55), preferred functional conditions, toxicity, bioactivity, bioavailability and underlying mechanism of action (Gad 2005, 55, 459). Candidate molecules are then formulated from chemicals into a medicinal format

such as a capsule, aerosol or injection together with the development of chemicals manufacturing process to reproduce the medical format on a commercial scale (Gad 2005, 469–481).

The main goal of preclinical stage is to determine APIs ultimate safety profile through toxicology testing and prepare an Investigative New Drug (IND) application (Gad 2005, 2–3, 56, 459). Preclinical toxicology testing is a critical feature of the drug and thus thoroughly scrutinized by regulatory entities (Gad 2005, 55–56, 458–459). The main parts of preclinical toxicology testing are: acute toxicology studies that investigate the effect of one or more dose over a period of up to 24 hours to determine toxic dose levels, repeated dose studies that are looking into the effect of prolonged exposure to the drug, genetic toxicity studies assess the likelihood of compound being mutagenic or carcinogenic, reproductive toxicity studies evaluate drug's effect on fertility, embryonic and post-natal development, whereas toxicokinetic studies examine the effects of toxic doses and address drug's clinical safety margins (Gad 2005, 56–57, 468–469, 476–477, 478–481; reference 56). Numerous guidelines such as those from FDA and ICH govern toxicology studies, which are required for filing an IND application (Gad 2005, 56). The application includes preclinical trials results and a characterization of API's (Gad 2005, 56, 459). The influencing factors chiefly involved in preclinical stage are: local science and technology, new technology output, local requirements, socio-cultural values, local technology acceptance and quality control risks.

2.5.4 Clinical trials

Clinical trials are planned to an extent during preclinical phase studies, which should be designed to support the clinical trials (Cayen 2010, 423, 425). Generally clinical trials are designed to be held in three phases or in four phases when there is a requirement for aftermarket approval trials or licensing (Kerr et al. 2008, 9). *Phase I clinical trials* titled human pharmacology studies are the first instance where a drug can be tested on a human being; they can be begun after IND filing if the study is not but on hold (Cayen 2010, 423–424; Kerr et al. 2008, 9–10). Phase I trials are closely monitored small-scale studies whose main goal is to discover if the drug is safe for humans but also to evaluate whether it causes side-effects and whether it has the desired effect (Cayen 2010, 423, 429, 441–443; Kerr et al. 2008, 10–12). They are used to evaluate pharmacokinetic parameters and tolerance in healthy adult volunteers, through single dose studies, dose escalation studies and short-term repeated dose studies (Cayen 2010, 427–438, 446–448).

Phase II clinical trials, known as therapeutic exploratory studies, are also small-scale trials but their purpose is to evaluate drug's preliminary efficacy and side-effect profile in 100 to 250 patients with the disease or condition under study (Cayen 2010, 449–450,

Kerr et al. 2008, 9–10). Phase II trials include further safety and pharmacology studies on top of those done *in vivo*, on living cells and *in vitro*, on the glass during preclinical stage (Cayen 2010, 450–451). Phase II clinical trials are done in preparation to larger phase III trials and are concerned with the short-term side effects and risks associated with the drug, whether the mechanism of action is the intended and does the drug have a positive impact on the condition (Kerr et al. 2008, 9–10, 13–14).

Therapeutic confirmatory trials or *phase III clinical trials* are large-scale clinical trials with 1,000–5,000 patients that test the safety and efficacy of the treatment in large patient population (Kerr et al. 2008, 10–11, 14–15). Results of the phase III are key in determining the overall safety of the drug and whether it can be given approval (Kerr et al. 2008, 10–11, 14–15). Preparations to applying for the Biologics License Application (BLA) or the New Drug Application (NDA) are started already when phase III trials are still held but applying requires them to be concluded. Phase III trials are the costliest and longest stage in pharmaceutical drug discovery and development, making up the bulk of the cost. Phase III trials usually involve a number of sites all over the world, presenting a monumental challenge to managing and coordinating all the sites.

Phase IV clinical trials are usually also large studies, which may be conducted after a medical intervention has been licensed for use and are sometimes required as a condition of licensing a new treatment (Kerr et al. 2008, 16). Phase IV trials may aim to define the treatment efficacy in a broad patient population, together with factors such as quality of life and the frequency of acute side-effects (Kerr et al. 2008, 16). They are also used to affirm new indications as well as to assess the cost effectiveness and implications of the intervention while comparing treatments' clinical advantages against either the standard of care or an investigational medicine (Kerr et al. 2008, 16).

Interest in participation on clinical trials from patients in Western world is low and many patients make for bad test subjects as they use a number of medications that complicate the trials, hence today pharmaceutical companies involve patients from a number of countries to participate in their trials (Shah 2003). Clinical trials are often held in developing countries where oversight is lax and the number of patients is vast (Shah 2003). The case in China is nowadays different with strict guidelines on the ethical codes of conduct for test but the potential number of patients is still truly vast. For the conduct of the trial, it is a huge benefit when one or few hospitals have access to a sufficient number of patients for the conduct of the trial with a fraction of medical costs. The case is made complicated by government regulations, such as those applied by the Chinese government and Chinese State Food and Drug Administration CFDA (CFDA 2012; China Pharmacopoeia Committee 2005), which may force companies to conduct R&D, such as the replication of studies for pharmaceutical registration (Boddewyn 1985). Market access, local and market requirements, customer information as well as the local advantage of sizeable patient pool and operating efficiency are factors influencing clinical phase drug discovery with greatest risk stemming from inadequate

healthcare, hospital or other infrastructure as well as governmental decision making in intellectual property protection and market approval.

2.5.5 *Pharmaceutical R&D value chain*

Outsourcing some activities has always been a common practice in the pharmaceutical industry (Crossley 2004). At first roughly about 50 years ago, outsourcing consisted mostly of marketing (Crossley 2004). This was followed after 10 years by parts of formulation such as medicinal chemistry and toxicology testing when in another 10 years most of the development processes and registration duties were outsourced (Crossley 2004). Discovery stage and especially hit to lead and lead optimization were the only parts hardly touched by outsourcing but it has become a more common practice as well after some years (Hätönen and Eriksson 2008; Crossley 2004). This process has many similarities to that of the internationalization of R&D in general (Ronstadt 1977). Also those parts of drug development that were first outsourced in the country of origin are also the same parts that seem to have been targets for the different organizational forms of globalization of R&D activities and much for the same reasons (Crossley 2004).

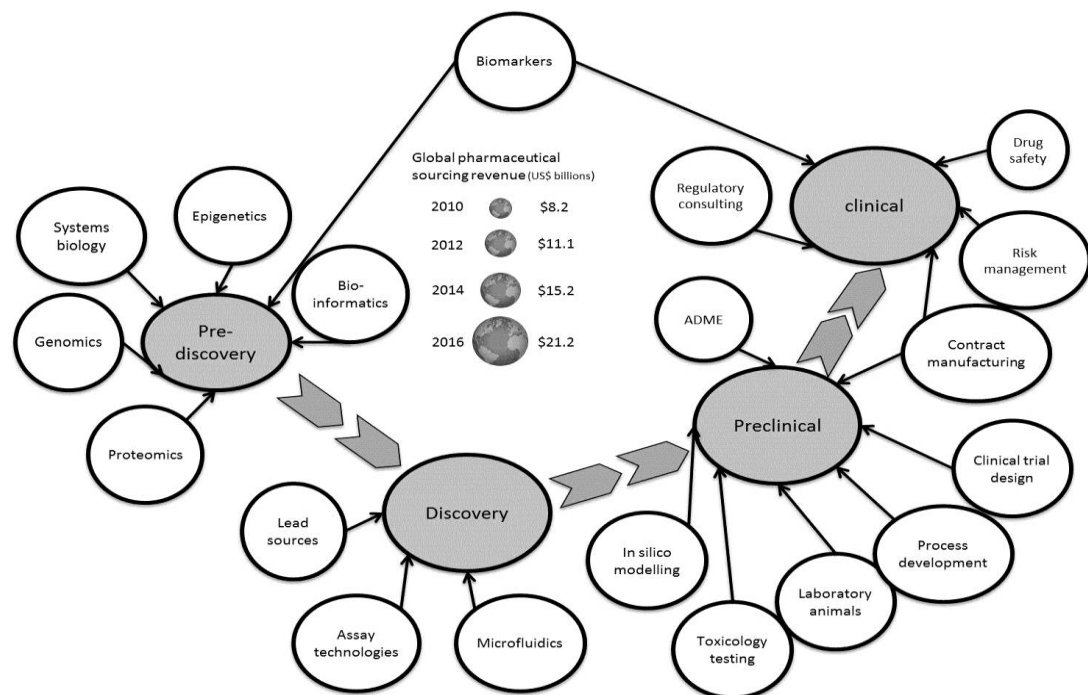


Figure 1. Different phases of drug development, their position in the value chain and relevant forms of sourcing agreements

Thus it is the drug development stage to be globalized itself that is one of the important factors in the decision. The span of R&D globalization in general, value chain activities of drug discovery and relevant sourcing agreements are presented in figure 1.

2.6 Initial Framework

This research is based on the conceptual understanding on the globalization of R&D derived from a review of contemporary literary on the subject. The general globalization of R&D activities has been researched from the point of view of centralization versus decentralization, in-house execution versus outsourcing as well as through its dispersion globally. This literature review is presented in detail in chapter 2. The literature review granted the author some assumptions on R&D globalization, which are depicted in the initial framework in figure 2.

Many factors affecting the R&D globalization process have been identified but none of them can sufficiently alone explain why companies partake in this global globalization of R&D. It is assumed in this research that firms pursue globalization of pharmaceutical R&D because they attempt to benefit from a single or a number of influencing factors related to the geographical globalization of R&D activities, as firms seek to exploit firm-specific capabilities in foreign environments (Kuemmerle 1999).

These factors affect together on a macroeconomic level, such as in a case of a country or an industry. A similar assumption is that on a firm level some influencing factors on R&D globalization are important to some firms when others seek other gains. As companies evaluate different options on exploiting these factors (Dunning 1958; Dunning 1995; Hymer 1976), it follows that pharmaceutical R&D globalization in a firm may be pursued through different forms of R&D globalization. These R&D globalization governance forms are: R&D offshore outsourcing, R&D offshoring or R&D internationalization. Academic literature on globalization of R&D activities explains how the concepts of R&D offshore outsourcing, R&D offshoring and the evolutionary internationalization of R&D process differ from each other. Based on these differences, the influencing factors on globalization of R&D have been associated with the different governance forms of overseas R&D globalization (Boehe 2008). Further assumption is that depending on what factors are of interest to the firm it should employ an R&D globalization mode suitable for the factors it wants to profit from. Depending on the firm's current situation and its future needs, it might prefer one of these three governance forms over the other two (Kuemmerle 1999).

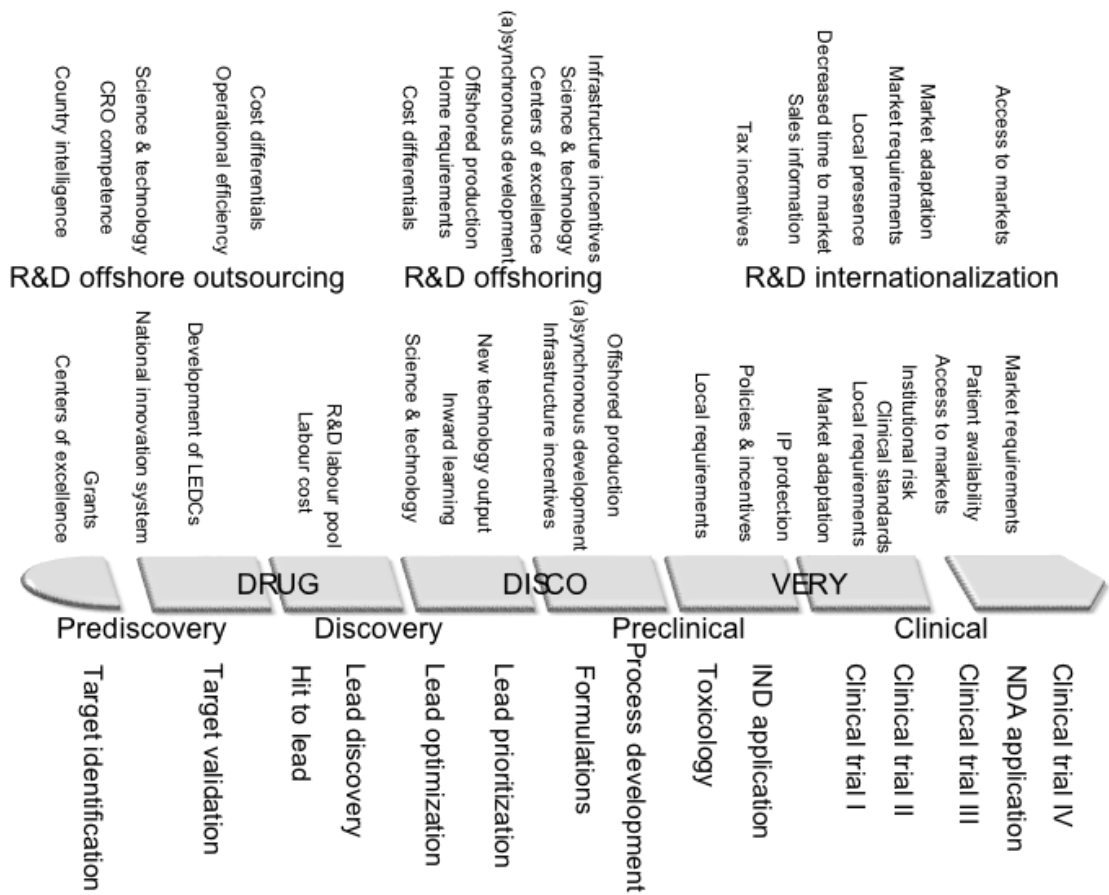


Figure 2. Initial framework on the distribution of influencing factors according to R&D globalization governance form and pharmaceutical drug discovery.

First decisions a company faces is whether to set up its own overseas subsidiary or engaging in some form of sourcing arrangements (Kuemmerle 1999). Offshore outsourcing and offshoring, although differently motivated, are both driven by cost reduction to some degree (Bardhan 2006). Nevertheless, as an only motivation, cross country cost differentials is only a clumsy way for cost cutting (Bardhan 2006). While cost is an important influencing factor, offshore outsourcing and offshoring are driven by other factors as well. R&D offshore outsourcing attempts to shift early stage financial risk associated with R&D by accessing external talent whose need is sporadic as a cost reduction (Bardhan 2006). Nevertheless it is chiefly a way to ensure access to best talent and knowhow of researchers from diverse disciplines (Sen and Rubinstein 1989). Rivoli and Salorio (1996) show that the decision between in-house R&D and contractual agreements should not be based only on the direct benefits but evaluate the long term potentials. Other factors encourage firms to choose R&D offshoring to own subsidiaries or research centers instead of offshore outsourcing (Ito et al. 2007). Factors affecting R&D offshoring have to do with government incentives (Hu 2007), previously off-

shored production (De Meyer and Mizushima 1989; Pearce 1989) and knowledge seeking activities (Ito et al. 2007). Knowledge is seen here in the form of regional requirements and on the need for product adaptation together with local market knowledge and country intelligence, which all affect firm's inclination to offshore R&D to its own overseas subsidiaries (Bardhan 2006). Internationalization of R&D activities follows an evolutionary path (Ronstadt 1977). It has been portrayed as a gradual exploitation of location specific advantages in technology intensive companies (von Zedtwitz and Gassmann 2004). Access to markets and access to local science and technology have been proposed as the major driving forces behind this development (von Zedtwitz and Gassmann 2002). Nevertheless, these driving forces are actually a combination of many influencing factors previously identified in literature, which individually or together provide motivation for firms to engage in internationalization of R&D. Although cost considerations play a role in R&D internationalization as well, the value generating factors appear to be driving the internationalization more than static cost considerations (von Zedtwitz and Gassmann 2002).

Depending on the tasks, the same factor affects firm's decision to globalize R&D differently (Ito et al. 2007). Separation of R&D to whether it is development or research that is globalized has been shown to affect the process (von Zedtwitz and Gassmann 2002). Different development tasks can vary from other development tasks (Iansiti 1993). Similarly, different research tasks may alternate such as basic research from applied research (Iansiti 1993). These can differ in nature as much as development varies from research (Iansiti 1993). Furthermore, depending on a firm and its strategic goals, a number of factors affect in a company specific way influencing the R&D globalization process (Kuemmerle 1999). Thus, the actual R&D function to be globalized, should be also taken into consideration as an influencing factor. It is argued in this paper that in the case of pharmaceutical R&D this separation can be viewed as separated on the lines of different stages of pharmaceutical product development. Thus this research assumes that the globalization of pharmaceutical R&D is dependent on the financial, scientific, managerial and operational requirements of the actual R&D function that is to be moved overseas.

3 METHODOLOGY

3.1 Research Approach

From the conceptual understanding derived from the academic literature on globalization of R&D could be understood that the phenomenon had received lot of both academic as well as industry attention and was extensively studied. Nevertheless a huge ideological difference could be observed on whether this process was driven by purely/partly by cost considerations or whether other influencing factors such as access to key growth market, large talent pool, sourcing of top talent, centers of excellence, global and asynchronous R&D organization, availability of flexible, cost effective, sophisticated CROs' and favourable investment environment were more important driving forces. Similarly a rift existed in whether this was a process of internationalization of R&D driven by changes in the world's economic landscape, which puts accessing markets in the emerging countries as the most important strategic goal, together with accessing technological excellence and knowledge in these locations or is this an extension of the off-shoring and offshore outsourcing practices already prevalent in other business functions.

Many researchers had already described different motivations as factors affecting R&D globalization and some researchers have made an effort to outline the characteristics of foreign R&D activities in China (Xue and Wang 2001; Li and Zhong 2003). This research is conducted to explore the R&D globalization governance forms for pharmaceutical companies in China and on, which factors they can capitalize when undertaking such an endeavour. The empirical analysis takes into account all three governance forms of R&D globalization. Thus the author attempted to design a study that would clarify the issue in the case of pharmaceutical industry on the conditions of PRC by disclosing the prevalent industry opinions and understanding.

To answer the gap left in literature there was a need to use the process of deduction, which is a method by which researcher attains reasoned confirmation of existing theories, to dismiss/conclude on the understanding of the phenomenon in existing literature (Burney 2008). By contrast induction is used to arrive to conclusions from an observed phenomenon by testing hypotheses and through pattern-recognition (Burney 2008). To reach an understanding of the phenomenon and to offer in the context of China a country specific and pharmaceutical industry specific framework, the author used a mixture of deduction-induction method. The findings already presented in the existing academic literature were affirmed based on the empirical research through the process of deduction, which bestowed reasonable confirmation of existing theories. A new framework was proposed by the author through the process of induction based on he observed phenomenon by testing hypotheses and via pattern-recognition. This research was ap-

proached through critical rationalism realizing that the researcher has made hypotheses based on conceptual understanding derived from academic literature and holding theories presented in the literature as premise against the real world (Popper 1972). And thus leading to research conclusions that precognitions and hypotheses presented have either gained corroboration or are refuted and knowledge is accumulated by conjectures and refutations (Popper 1972).

3.2 Research Method

As the research on the phenomenon was based on opinions and understandings, it had to be seen as resulting from choices made by humans or groups of people based on analysis of individuals or groups of individuals and in that case to be subjective. In this way it was presumed that people value same things as well as different things in dissimilar ways. Here the author take into account the questions of reality and constructed reality as a social sciences problem "what is real" by analyzing also the potential bias of these individuals or groups of individuals. Thus qualitative research approach, that emphasizes subjective view, was needed to gain a deep understanding of the phenomenon as seen and understood by those who shaped it.

Qualitative research is always research of the human world in its social context as opposed to quantitative research that can be applied to both to the human world as well as to natural sciences, and which is suitable to any- and everything that can be measured and quantified. Qualitative research by its definition is a research approach, which thrives to scientifically answer questions by using predefined rules and steps to solve it together with collecting evidence leading to findings and conclusions not determined in advance and yielding results applicable beyond the borders of the research settings (Mack, Woodsong, MacQueen, Guest and Namey 2005, 1).

Taking into account this papers exploratory nature, the research is based chiefly on interviews with pharmaceutical managers, directors and other professionals with previous experience in China, together with knowledge freely available from Internet sites and official Chinese publications. In the early stages of research, the qualitative interview method is widely considered to be appropriate in navigate unclear boundaries between and the context and the phenomenon. This is especially true in cases where contemporary events are examined in the research question, and when only a minuscule amount or no control is expected over behavioural events.

Qualitative study in this paper generally relies on in-depth expert interviews as the primary data source and validating results with secondary data such as company press releases and internet research. In 2012, eight interviews have been conducted for this study with senior pharmaceutical managers and other similar professionals working on pharmaceutical R&D activities in China. The eight interviews conducted represented

knowledge from seven (Pfizer, Johnson&Johnson, GlaxoSmithKline, Merck, Bayer, Eli Lilly, Novartis) of the twelve major pharmaceutical companies of the world. All the companies that the interviewees worked or had worked in China were based in Western countries, and each had a significant and traceable history in China.

3.3 Research Settings

The basic unit to be analyzed in this research is comprised of the understanding of the phenomenon by key personnel working in International pharmaceutical companies that have average R&D intensity on the company level or at minimum on the business level equal or higher than 10%. Choosing this company inclusion criteria in the research enables the scrutiny of R&D as independent from other functions of the company and is a criteria used in other studies on the field (Gerybadze and Reger 1999), which validates comparisons. The basic unit of research is further divided into their understanding of the phenomenon on the level of individual phases of pharmaceutical drug development of the above-mentioned companies. The key personnel selected for the interviews were at least in middle management positions to ensure sufficient knowledge of the subject. Preferably the interviewees were selected as those associated with management of research and development, strategic management or from management of sales and marketing if sufficiently knowledgeable on the subject of pharmaceutical R&D.

The geographical area for this research is chosen based on literary findings, which indicate that the locations of foreign R&D labs in China, with an overwhelming majority 89% of all foreign R&D laboratories, are concentrated along a relative short strip of land between Beijing and Shanghai (von Zedtwitz 2004). Von Zedtwitz (2004) also reports that Shanghai hosts the majority of companies in the food, pharmaceutical and engineering industries, while Beijing tends to be the preferred R&D site for companies in telecommunications and electronics industries but also hosts pharmaceutical firms.

The research was conducted by the author between September 2011 and May 2012 in China, with majority of the study and interviews taking place in Shanghai notwithstanding an almost two month research trip to Beijing, where three interviews were agreed and executed. Part of the research in Beijing included a pharmaceutical conference and a social event, which both the author attended. The author also collected information on the pharmaceutical industry in China during a shorter research excursion to Hainan, where one interview was conducted. While in Shanghai the author participated in two conferences or seminars and on a university lead event. The research was conducted solely with the resources and networks of the author, notwithstanding substantial assistance from Chinese and foreign friends or acquaintances, as well as invitations and introductions from the heads of Finnpro in Shanghai and the Fudan Nordic centre.

3.4 Data Collection

In this study, the author has generally relied on in-depth expert interviews as the primary data source. In addition, secondary data has also been collected to complement the primary data. The secondary data includes official Chinese publications, company press releases, and information available over the internet. Data derived in such a way affects the characteristic of knowledge acquired by scientifically analyzing the underlining phenomenon through explaining and predicting it via actions in social reality by searching for regularities and causal relationships among the factors of the phenomenon, as is described by the positivistic nature of knowledge (Pitkäranta 2010).

The reason behind selecting 'interviews' as the primary data collection method is that interviews are an established and often used way of gathering research material and conducting qualitative research (Eskola and Suoranta 1998, 65–72). The purpose of an interview is through an interviewer initiated and guided discussion, to determine the opinions and impressions of the interviewee on a subject (Eskola and Suoranta 1998, 70–77). The idea of an interview is beautiful in its simplicity and sense; when the author want to know something about a person: what he is thinking, what are his motives, ect., why don't the author ask him directly (Eskola and Suoranta 1998, 65–72). The clearest definition of an interview is a situation where the interviewer asks questions from the interviewee although this definition has greatly been expanded to more coincide an actual conversation (Eskola and Suoranta 1998, 65–72).

In addition, an interview is an interaction, where in both parties affect each other. The interview situation is affected by both the interviewer and the interviewee as well as physical, social and communication related factors (Eskola and Suoranta 1998, 70–77). The situation is abnormal in a sense that it is usually: premeditated, interviewer initiated and guided, interviewer generally has to motivate the interviewee, the role of the interviewer is known to himself and picked up by the interviewee, in addition the interviewee has to be able to trust that his personal information and answers are handled confidentially (Eskola and Suoranta 1998, 70-77).

Qualitative research's purpose is the conceptual understanding of the world, in which both theoretical concepts and their empirical equivalents are needed (Eskola and Suoranta 1998, 75). Theoretical concepts are forged into empirically measurable units through the process of operationalization (Lehtinen 1991, 17). Thus each concept has two definitions, a theoretical one that binds and explains its relationship to other theories as well as an operationalistic one that brings an measurable definition to the theoretical framework and connects it to the reality (Harisalo et al. 2002).

The methodological basis for operationalization is the idea of transferability evident in positivistic philosophy of science. Another basis is the test of semantic empiricism that purposes that words and sentences always share the same meaning regardless of user, context, time or place (Eskola and Suoranta 1998, 75–76) Operationalization is

based on natural science theory and its use in quantitative studies and humanities has been criticized extensively and the discussion is ongoing, here it is applied on the basis of socialistic constructiveness that states all scientific concepts and theories to be over-time agreed treaties (Eskola and Suoranta 1998, 77). The author has used the process of operationalization to account for this discussion and enhance the transferability of this research as shown in table 3.

The Research Question	The Research Sub-Questions	The Operational Equivalents	The Operationalized Questions
How to determine the appropriate governance forms for globalization of pharmaceutical R&D for international pharmaceutical companies in the context of PRC based on the influencing factors?	What are the different factors influencing the internationalization of pharmaceutical R&D to PRC?"	The influence of market, adaptation, and incentives.	What is the return from sales and incentives to cost generated from market entry and adaptation.
	What are the different factors influencing the offshoring of pharmaceutical R&D to PRC?"	The influence of centres of excellence.	What is the value generated for the end product?
		The influence of local science and technology.	What is the value of local science and technology?
	What are the different factors influencing the offshore outsourcing of pharmaceutical R&D to PRC?"	The influence of labour pool.	What is the value of R&D labour supply surplus?
		The influence of cost and incentives.	What is the amount of cost savings and operational efficiency to initial investment?
		The influence of risks and minimal conditions.	What is the cost of infrastructure, IP protection, training and the potential impact of risks?
	How do the different phases of pharmaceutical product development process influence the dispersion of pharmaceutical R&D in the context of PRC?"	The requirements for pre-discovery.	Which factors have an influence on pre-discovery phase
		The requirements for discovery.	Which factors have an influence on discovery phase
		The requirements for pre-clinical.	Which factors have an influence on pre-clinical phase
		The requirements for clinical trials.	Which factors have an influence on clinical phase

Table 3. Operationalization of the main research question, as well as the subquestions of this study together with the different forms of R&D globalization and their relationship to influencing factors

The main research question, as well as the subquestions of this research are operationalized in table 3, with the purpose of clarifying the relationship of influencing factors presented in literature on globalization of R&D to different patterns of globally dispersing R&D activities. In the next section, following the guideline provided by Hart (1991), the interview process of this study is described in a detailed manner.

3.4.1 Selection of the Interviewees

All the interviews were gained through social contacts and networks, called "quanxi" in Chinese, either in professional context or through friends and acquaintances. It is believed that the validity of data gathered for this research is enhanced further as a personal contact existed between the interviewer and the interviewee. This is because the interviewee would have a higher motivation to be frank and communicate his views and perceptions accurately and truthfully. The interviewees, who all work in the pharmaceutical industry or in related professions, were selected because of their expertise in the industry, especially in the context of China and represent knowledge from seven (Pfizer, Johnson&Johnson, GlaxoSmithKline, Merck, Bayer, Eli Lilly, Novartis) of the twelve major pharmaceutical companies.

All the interviewees work in at least managerial or specialist level positions, they were selected to have different operational positions and diverse knowledge from pharmaceutical R&D and the different parts of product development pipeline. The list of the interviewees and the associated relevant information are illustrated in Table 4. Following the table, detailed description of each of the interviewees are provided.

Name of the interviewee	Organization	Position	Expertise and/or experience	Interview date and Duration
Dr. Tang	Pfizer	Senior director	Extensive R&D, Pharma & China	13.01.2012 63 min
Donald Wyatt	Wyatt group	Founder	Extensive Pharma and China	05.01.2012 42 min
Lisa A. Kilday	Patent Protocol	Patent Attorney and Principal	Extensive Pharma and R&D	31.12.2011 10.01.2012 6&34 min
Freesia Chen	GSK China	Supply Chain Manager	Extensive China Moderate Pharma	01.11.2012 29 min
Rogers	Johnson&Johnson	Clinical Trial posting specialist	Extensive China Moderate Pharma	07.12.2011 17 min
Dr. Zheng	Lundbeck Research China	General director and head	Extensive R&D, Pharma&China	12.01.2012 38 min
Dr. Max Von Zedtwitz	Tongji and other University	Professor and Director of Glorad	Extensive R&D and China Moderate Pharma	12.01.2012 40&6 min
Nick	Johnson&Johnson	Marketing	Extensive China Moderate Pharma	20.02.2012 19&2 min

Table 4. List of interviewees for this study and their associated details

Dr. Boxiong Tang (唐伯雄) is a senior director of Emerging Markets Outcomes Research team at Pfizer (辉瑞公司新兴市场高级总监), responsible for outcomes research in specialty care products and Asia region. He has over 18 years' experience in medicine, health services and outcomes research. He received his M.D. in preventive medicine, Ph.D. in health services research and a M.P.H. in the major of international health. Prior to Pfizer, Dr. Tang was the director of Health Economics and Clinical Outcomes Research in Johnson & Johnson and GlaxoSmithKline, where he was responsible for health outcomes research in biologics and oncology. Dr. Tang has published many manuscripts in the peer review journals and presentations in the international scientific congresses. Dr. Tang was selected to be interviewed due to his extensive knowledge on pharmaceutical R&D and specialization on the Asia region and on China especially. He has worked with a number of Chinese academics, researchers and companies in the pharmaceutical field and is privy to many decisions in the above-mentioned companies in regards to moving operations and conducting R&D in PRC. For his views on moving R&D to PRC and on the influencing factors there is a potential for bias in the sense of China as his home country, from his long stay in the United States where he has studied and worked for a number of years, a bias in opinion may also exist due to his other affiliations to Chinese companies such as CROs.

Donald W. Wyatt is the founder of The Wyatt group. He has extensive experience in intellectual property, has served as a researcher in Merck, a large pharmaceutical company, an attorney in a law firm, patent counsel at a Fortune 500 company and as Vice-President of Legal Affairs and Corporate Secretary at a biopharmaceutical company. He has acted as lecturer in Fudan university, one of China's top universities. Mr. Wyatt was selected to be interviewed due to his extensive understanding on conducting manufacturing and R&D operations in China. He has a lot of hands on experience on the realities of conducting operations in China in regards to infrastructure, working culture, educational system. From his legal and consultative work for major pharmaceutical clients he has detailed knowledge on moving operations such as R&D to PRC and many of the influencing factors behind the decisions. For his views on moving R&D to PRC and on the influencing factors there is a potential for bias from his early experiences on doing business in China, potential for bias also exist from his long work history in the United States on the time of US hegemony in pharmaceutical R&D. A bias in opinion may also exist due to his affiliations to clients in China or other business interests. He may also have been restricted on sharing some information that would be considered confidential.

Lisa A. Kilday is a registered Patent Attorney and the Principal of Patent Protocol, a law and consulting firm focusing on the procurement and protection of intellectual property. Mrs. Kilday has over fifteen-years of experience in intellectual property. She was an associate in the international law firm of McDermott Will & Emery LLP based in the Washington, D.C. office. As a member of the Intellectual Property, Media &

Technology Department, she focused her practice on patent prosecution and counseling. Prior to joining McDermott Will & Emery, Mrs. Kilday was a patent law clerk and Intellectual Property Law associate with a D.C. law firm specializing in the preparation and prosecution of electrical, electromechanical, and chemical applications. Mrs. Kilday was selected to be interviewed due to his extensive understanding on the intellectual property in southeast-Asia and especially on the acute understanding of the level of biopharmaceutical research in China. She has had many clients from the pharmaceutical industry. She may also have been restricted on sharing some information that would be considered confidential.

Freesia Chen is a Supply Chain Manager at GSK China on Vaccines. She has worked in China in the pharmaceutical industry for almost ten years. She has worked first for Eli Lilly with prescription medicines and other pharmaceutical products. After that she has then worked for Novartis in vaccinations business until last year when she started working in GlaxoSmithKline as a Supply Chain Manager on Vaccines. Mrs. Chen was selected to be interviewed due to his varied knowledge working for three major pharmaceutical companies in China as well as his specialization on vaccinations, an important pharmaceutical product category. Mrs. Chen has extensive, local knowledge based on his work experience as a local in China's pharmaceutical sector.

Rogers is a Clinical Trial posting specialist at Bayer China. He is a Chinese national and has been educated in a Chinese university. He has worked more than 5 years in his current post and has other work experience in the pharmaceutical and healthcare industry. Rogers has extensive, local knowledge based on his work experience as a local in China's pharmaceutical sector.

Nick works at Johnson & Johnson China marketing department being responsible for medical products of Johnson China Marketing. He is Chinese national and has been educated in a Beijing medical university. Based on his medical studies he has fairly good understanding of medical research and the pharmaceutical industry. He has less than 10 years of work experience in Johnson & Johnson and comparable companies. Nick has extensive, local knowledge based on his work experience as a local in China's pharmaceutical sector.

Dr. Zheng Li is the General Manager and Head of Lundbeck Research China. He received a PhD in Neuroscience and Behaviour from the University of Massachusetts, Amherst. He has worked as a Research Fellow and Postdoc for the University of Michigan after which he started working as a Senior Scientist at Parke-Davis Pharmaceutical Research for half a decade and as a Principal Scientist at Pfizer for almost a decade. From Pfizer Mr. Li transferred to Lundbeck Research USA where he worked as a principal Scientist/Team Leader until 2011 when he was appointed as the General Manager of Lundbeck Research China. As a General Manager of Lundbeck Research China Mr Li has build relationships with leading academic institutions in China and assisted in establishing contacts with contract research organizations throughout China. Dr. Tang

was selected to be interviewed due to his extensive knowledge on pharmaceutical R&D, specialization on China and on the outsourcing to Chinese contract research organizations especially. A potential for bias may exist from his recent promotion to manage the outsourcing of certain Lundbeck functions to Chinese contract research organizations. His many years of working in the US for major pharmaceutical companies may also affect his view of the influencing factors in globalization of R&D to China.

Dr. Max Von Zedtwitz is a leading academic in the field of global R&D management and reverse innovation. He is a professor of international business and innovation in Tongji University (China), University of St. Gallen (Switzerland), Grenoble School of Management (France), Chalmers University of Technology (Sweden) and Nyenrode Business School (Netherlands). He is an independent advisor and consultant on innovation and China as well as director of GLORAD, the Research Center for Global R&D Management and Reverse Innovation. Previously he has acted as a former President, AsiaCompete Int'l Ltd. (Shanghai), former Vice President, PRTM Management Consultants (Shanghai) Ltd. In his past academic career he has acted as a former Professor of Innovation, Technology Management, and Strategy at IMD, Tsinghua University, and Peking University. Dr. Max Von Zedtwitz was selected to be interviewed due to his extensive knowledge on R&D globalization, specialization on China and expertise on high technology sector including pharmaceuticals. Potential for bias may come from his academic outlook on the subject, this can materialize itself through prepared pre-formulated answers based on academic knowledge instead of based on day-to-day events.

In addition to the above interviewees, the author initially considered collecting primary data from other potential persons. However, the plan was abandoned due to practical reasons. The potential interviewees included the owner of pharmaceutical CMO Company located in Tianjin whose company specialized in producing pharmaceutical bulk ingredients for export to US and Europe, a researcher in China's state cancer research centre and a manager of a small western pharmaceutical company contract manufacturing OCT-medicines for bottom of the pyramid (POB) -market in southeast-Asia. Further two interviews were planned and proposed but could not be achieved because of time and place constraints, who are as below:

Dr. Karen Atkin is vice president of AstraZeneca R&D in China, she joined AstraZeneca 13 years ago. In this role, she leads the company's Chinese R&D organisation, with a focus on achieving a step change in speed, quality and customer focus in the delivery of both new products and medical affairs. Karin Akins has reshaped AstraZeneca's business model to add new capabilities and tap into external collaborations and partnerships. I was supposed to also analyze her lecture "The Power of Partnering: How to creatively expand the innovation network". The interview and analysis of the lecture could not be organized because of illness related cancellation of her lecture.

Dr. Jeremy Teo leads the Pharmaceutical R&D sub-practice for McKinsey in Asia. He has worked in R&D in the US, Europe and Asia, hosts a regular Quarterly Heads of Pharmaceutical R&D Roundtable in China and is a regular speaker and panelist at industry conferences. Dr Teo is a Physician by training with clinical training at the National University of Singapore and Yale School of Medicine. He also holds a Masters in Molecular Immunology from Harvard University and an MBA from INSEAD. Analysis of his lecture on "Pharmaceutical R&D in China - Reality or Myth?" was also proposed but could not be achieved due to cancellation of the lecture for a business trip.

3.4.2 Arranging the Appointments for Interviews

All interview appointments were gained through personal contacts or via introductions from friends or acquaintances together with the utilization of networks by the heads of Finnpro Shanghai and Fudan Nordic centre. The first contact to all interviewees was made through face to face meeting in a conference, seminar or a social event, unless it was the result of an introduction by a friend or acquaintance, in which case the first conversation was through an email, skype or a phone. After getting to know one another a more formal interview was scheduled in the interviewee's office or in a public place, such as a cafeteria, restaurant or hotel lobby according to interviewee's wishes. In cases where the first contact was a face to face meeting in a conference, seminar or a social event and conducting the interview straight away fitted both the interviewee and the interviewer part or the entire interview was conducted then and there in places, such as a restaurant or conference space or hotel lobby. When arranging the time interviewees were informed that the simplistic interview takes about 25 minutes. In one of the interviews this time was exceeded due to a bathroom break and after the scheduled time was exceeded in another interview, the requested time was extended to 40 minutes. However in few interviews with interviewees who possessed extraordinary amount of in-depth knowledge on the subject even this time was exceeded. The following examples are given to illustrate the importance of social networks, personal contacts and conferences as venues for such meetings, as well as to illustrate the relaxed nature of these interviews.

An interview with a senior pharmaceutical director was held in a hotel lobby in Shanghai. The interview took place after a conference on R&D and innovation in China that was scheduled to be centred on the pharmaceutical industry. The author unknowingly met the interviewee in question on the Shanghai metro. Unaware of each other's destinations the author and the interviewee met again in the conference, where they chose adjacent seats and conversed on the conference topic and other topics of mutual interest. During the conference break, the author described his research topic and pro-

posed an interview, which was readily accepted by the interviewee, who proposed that it would be conducted in the lobby over refreshments.

Another interview was arranged in Beijing over a phone with a pharmaceutical manager through an introduction from a long time Chinese friend. The actual interview time was arranged via email and it took place in the interviewee's office. The interviewee and interviewer had much in common and the actual interview was preceded by a lengthy conversation on mutual friends and acquaintances.

3.4.3 *Handling the Interviews*

The interview types can be divided in multitude of ways, and many categorizations exist (Rubin and Rubin 1995, 56). Simplistic classification and the one used by the author can be achieved by taking into account the degree of structuring on the questions and the extent the interviewer is parsing the situation (Eskola and Suoranta 1998, 77). A semi-structured interview is a one where the questions are the same for each interviewee and asked in the same sequence but is void of structured answers and encourages free expression (Eskola and Suoranta 1998, 77). In a theme interview the subject matter and themes are predetermined but this method lacks the structured prewritten questions, sequence and answers. In this interview type the interviewer makes sure that all predetermined themes are covered but their extent and sequence are varied from each interview. In this method the interviewer has a framework of themes but not a readymade list of questions (Pitkäranta 2010).

The interview method used by the author is a mixture of the two above mentioned where the author had predetermined an theme and a list of questions, the theme was introduced to each interviewee but questions were not asked in the same sequence and the extent of each question varied from an interviewee to interviewee and additional non predetermined questions were asked to facilitate conversation and deepen the interaction on a theme when necessary (Pitkäranta 2010). This mixture of methods and flexibility of the situation increased the trust between parties as well as facilitated deeper knowledge transfer and enabled the interviewer to increase the reliability of the data.

To combine the advantages of unstructured and semi-structured interview methods, the interviews were started with introduction of theme, then open-ended questions, with the option of further unprepared questions followed by a structured questionnaire protocol (Pitkäranta 2010). The interviews were started by introducing the theme and asking formal open ended questions regarding the companies' motivations and goals on their R&D activities in China, together with what organizational structures and forms of entry they utilized.

3.4.4 *Timing the Interviews*

As reported on deep interviews there is a problem related to time constraints and in all the interviews conducted by the author the slated time frame of the interview was exceeded. In these cases the interviewee where asked if he would want to continue and the interview extended. The interviewees where not deliberately lead astray over the required time and the interview times provided would have been sufficient for the intended questions (Eskola and Suoranta 1998), but the extra time required for the unprepared questions and follow-up questions on topics could not be calculated and varied between interviewees. All the interviewees expressed interest to continue the interview and where in no hurry to conclude and after no questions were asked any more, all the interviewees provided topics of their own and offered their insights on the theme in question.

Furthermore, in most cases the discussion was continued on personal level and through friendly chatter after the interview situation was concluded. In one case, the interview was suspended for a bathroom break and another interview was put on hold for a seminar dinner when the seating was not suitable for the unceasing continuation of the interview. All the interviewees where given a choice to as to the time and place of the interview (Eskola and Suoranta 1998), and many interviews were conducted from their explicit request either at their office or in social settings, such as a cafe or a restaurant.

3.4.5 *Directing the Content*

The validity and reliability of the obtained data was further increased by conducting deep interview in a sense that some of the interviewees where contacted more than once and follow up questions where presented (Eskola and Suoranta 1998). The validity and reliability are further increased as well as the notion of deep interview readily achieved, through the compact subject and theme of the research (Kortteinen 1982, 296). As part of good interview etiquette, the purpose and the organizations involved in the research where disclosed (Pitkäranta 2010).

Besides asking formal questions, interviewer strongly encouraged the interviewees to describe their feelings, observations and personal views on the subject as well as to provide related examples from their daily business, including current projects. The information obtained in this way was crosschecked with secondary data. This kind of triangulation allowed the author to minimize the bias of personal perspective and enhance the validity of the information.

3.4.6 Collection of Secondary Data

In addition to the primary data, secondary data from several sources have been collected for this study. The main reason of collecting secondary data was to increase the reliability of the complete data set. Secondary data collected for this study were fitting with the primary interview data, and both the data sets complemented each other perfectly.

The first source of the secondary data was the official websites of the firms with, which the interviewees are associated. The company web-sites often contained valuable information, including press releases over the years regarding the internationalization of R&D activities of the firms. In addition, information regarding the firms' goals, objectives and future expansion plans also helped to provide important insights.

The second source of complementary data was articles and pieces published in magazines as well as managerial oriented journals in China. The author chiefly relied on English language publications such as Xinghua and China daily but through a help of a translator and a moderate knowledge of Chinese was able to access Chinese language publications as well.

Another source of complementary data were Chinese government publications such as the 2005 and 2009 Chinese pharmacopoeia's published by the Chinese pharmacopoeia commission as well as white papers published by for example, China CDC (centre for disease control), Chinese health statistical digest in 2012. Similarly, those papers and guidelines published by other relevant government agencies, for instance SHPMCC (SHPMCC, 2012) along with GMP rules and additional publications by CFDA (CFDA, 2012).

3.5 Data Analysis

3.5.1 Use of Content Analysis

After the data collection has been complete, the researcher moved to the data analysis phase of this study. To analyze the collected data, the researcher used content analysis method. As objective of the researcher is to describe the views of key pharmaceutical industry personnel on globalization of R&D, content analysis was deemed appropriate to discover the opinions or the interviewees regarding the phenomena.

Content analysis is a scientific method, which achieves to reach conclusions from verbal, symbolic or communicative data. Its objective is to analyze documents, which can be books, articles, diaries, letters, speech, discussions, reports or interviews that have been rendered to a written form. According to Stemler (2001), content analysis is:

“a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding.”

Another broad definition of content analysis was provided by Holsti (1969), who argued that content analysis can be defined as “any technique for making inferences by objectively and systematically identifying specified characteristics of messages.” To test the theory presented on academic literature on the globalization of R&D processes the author have chosen a theory-guiding content analysis method. In theory-guiding content analysis the classification of the analysis is based on afore described conceptual framework, which can be a theory or a system of concepts. In theory-guiding content analysis the concepts come ready prepared as something known from the phenomenon already.

Another reason for using content analysis in this study is that as a scientific method, it enables to reach conclusions from verbal, symbolic or communicative data. As objective of the method is to analyze documents, which can be books, articles, diaries, letters, speech, discussions, reports or interviews that have been rendered to a written form. In addition, the method is suitable for analysis of unstructured as well as structured material, is extremely sensitive to context and is used to search for meanings. (Grönfors 1982; Krippendorff 1989; Kyngäs and Vanhanen 1999; Tuomi and Sarajärvi 2004)

3.5.2 Analysis Frame

With qualitative research interview the author seek to describe and find the meanings of central themes in the view of the subjects. Thus the central requirement for interviewing is to understand the meaning of what the interviewees say (Kvale 1996). In theory-guided conceptual analysis this is done by firstly forming the analysis frame, which can be extremely loose or structured (Pitkäranta 2010). To facilitate a simpler data collection and interpretation, taking into consideration the inexperience of the interviewer, the author have chosen to use a structured analysis frame. The structured analysis frame the author has used is depicted in figure 3.

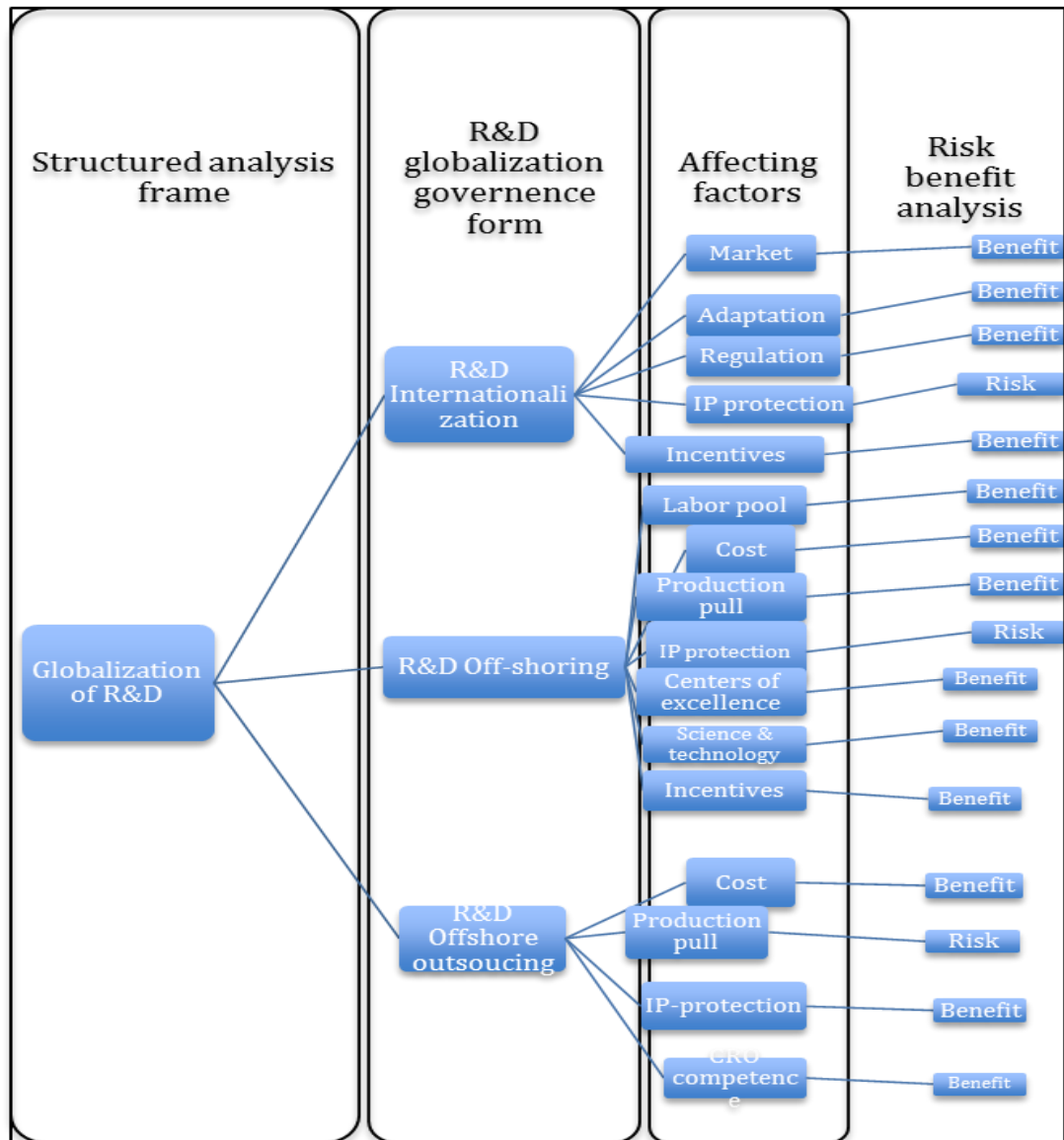


Figure 3: Structured analysis frame for theory-guiding content analysis of qualitative interviews of key personnel employed in pharmaceutical industry on the globalization of R&D to PCR

3.6 Generalization of research findings and trustworthiness

The great challenge in qualitative research is the assurance of scientific eminence and dependability of the study (Hägerström 2010). The research has to ascertain the association between the results and reality (Hirsjärvi et al. 2001, 128). The transparency of the research can be increased by implementing different evaluation criteria, thus providing opportunities to identify its strengths and limitations. The naturalist view of trustworthiness presented by Lincoln and Guba (1985) proposes the implementation of naturalistic trustworthiness criteria that includes four concepts: *credibility*, *transferability*, *reliability* and *dependability* (Marshall and Rossman 1989; Lincoln and Guba 1985). In this

study the author partly ensured credibility by provably identifying and describing the subject accurately (cf. Lemmetyinen 2010, 65). As mentioned in the data collection part, the interviewees for this research were selected with careful consideration of their expertise in China, the pharmaceutical industry and pharmaceutical R&D. To further ensure its credibility the interviewee's responses are documented extensively throughout this study together with their expertise and possible intrinsic biases.

The strength of qualitative research lays in the flexible and direct interaction between the interviewer and the respondent, which ensures the good transferability of information and knowledge (Sykes 1990). For the purposes of increasing transferability, Ödman (1979, 78) proposes the usage of multiple sources and studying secondary material (Bergum 2009). Transferability was achieved in this research by selecting and collecting empirical data from many interviewees with diverse backgrounds, expertise and positions but similar in their extensive knowledge of some part of the phenomenon. Hence it is expected that the findings of this study can be beneficial and useful to researchers, managers and other practitioners in the pharmaceutical industry. Reliability of a study is a strong measurement of the study's scientific standing. As the researcher can influence the results of an empirical study, the researcher himself is an important factor in data collection and analysis (Bergum 2009, 70) The researcher can either influence the data collection by affecting interviewee's responses or impact their interpretation and thus influence data analysis, which is another central part of the researcher's work (Bergum 2009, 70). Marshall and Rossman (1989) argue that researchers can respond to the demand for replicability in qualitative research by keeping carefully prepared and comprehensive notes and records that provide an audit trail and illustrate the rationale behind researcher's results and interpretations. The main research question and the subquestions are operationalized in detail to establish the reliability of this study. The raw data from all interviews, together with general analysis, are kept as computerized audio files and transcripts for future records. The reliability of results was further increased by taking into account the concept of constructed reality and potential bias of interviewees by coding the answers of each interviewee randomly with mathematical variables t, z, a, b, c, d, x, y while simultaneously providing anonymity for interviewees.

The last part of the naturalistic trustworthiness criteria is Dependability. Dependability refers to the extent that changing settings are standardized or randomized in the phenomenon being studied, so as to minimal affect the results (Lemmetyinen 2010, 67). Hence reliability was increased in this study with adoption of the theme interview method and semi-structured questions, which enabled the respondent to freely ponder the phenomenon and explicitly express their thinking rather than being influenced by the researchers questions an opinions or being limited by options provided by the interviewer. Similarly the interviewees were not limited by time constrains as all the interviews were held at a time of their choosing, majority in an environment of their choosing or other vice considered positive. Also the timing of the study need to be taken into

account as all the interview were taken between November 2011 and February 2012, well after the Twelfth Five-Year Guideline and its emphasis on high technology industries such as pharmaceuticals and biotechnology. Thus the results should already take into account the changed environment. Similarly the interviews took place well before the pharmaceutical bribery scandals around Big Pharma in 2013, which might have affected the interviewees' responses and willingness to share information.

Based on the nature of qualitative research it is evident that limitations are unavoidable. Qualitative research deals with subjective knowledge and concentrates on questions concerned with dimensions of the social worlds. Thus a good qualitative research focuses on accurately displaying the respondents' conceptualized subjective meanings, activities and social interactions (Fossey, Harvey, McDermott and Davidson 2002, 717). As the research on the phenomenon was based on opinions and understandings, the author recognizes that in this context the research has some limitations. Primarily the research has focused on one specific industry pharmaceutical industry, with an emphasis on Big Pharma. Subsequently, the results are not fully applicable to adjacent industries, such as biotechnology (cf. Yin 2003). Nor are the results completely transferable to different size companies in the pharmaceutical industry, although this was an issue discussed in the interviews and researched in the supporting secondary data (cf. Yin 2003). Secondly, the data collection is based on a limited sample on interviewees on a single data collection periods. A greater number of responses during a longer time frame could have provided a more reliable result and a better understanding of the phenomena. The above mentioned limitations were controlled with the careful selection of the interviewees, together with selection of the geographical and industry specific representativeness of the research. As the area spanning from Beijing to Tianjin and Shanghai holds 89% of all R&D operations by foreign companies and Shanghai in practice host all of those by pharmaceutical companies this research can be generalized to represent all pharmaceutical R&D by international pharmaceutical companies in PRC. In those aspects where the influencing factors are derived from the conditions, institutions or characteristics of PRC, the research findings only apply to it. In those aspects where they stem from low salaries or substantial ready supply of college graduates, they can be seen to apply to some extent on other Newly Industrialized Countries (NICs) if they are carefully evaluated keeping in mind the conditions of PRC on institutional, infrastructure and market level. Nevertheless, this study has ascertained the rationality and trustworthiness of the research by several means and thus should provide reliable findings within the limitations of this study (cf. Raukko 2009, 346).

4 EMPIRICAL RESEARCH

4.1 Objectives for R&D globalization

For the purposes of this research, an empirical study was conducted from the perspective of the pharmaceutical industry in the case of People's Republic of China. The study was performed to confirm the factors of R&D globalization and their relations to the forms of dispersing R&D activities globally. As described previously in this paper, these R&D globalization forms are R&D offshore outsourcing, R&D offshoring and R&D internationalization. This research scrutinizes individual factors or sets of factors on pharmaceutical R&D globalization that a firm wishes to pursue. The purpose of this research is to illustrate the relationship between these influencing factors and the most beneficial mode of geographical R&D globalization associated with specific factors.

4.1.1 *Cross country cost differentials and financial incentives*

According to the interviews conducted for this study, the author has reached the following conclusions. According to this study, cost considerations are an influencing factor in all forms of R&D globalization. In the case of PRC, this includes cross country cost differentials together with costs stemming from infrastructure. In essence, costs can apply to industries that experience strong cost competition in relation with high R&D requirements and costs (Cheng and Bolon 1993).

Interviewee x: *“I think that the major emphasis is cost. [...] If I look at the pharmaceutical industry in general, it's R&D that's the major overhead cost, and unfortunately this is a risk posing upfront cost, way of addressing it (reducing risks) is by reducing the R&D costs in general [...] when I say cost, it's also the ability to do more for the same money. [...] The competitive advantage of China is purely cost. It's purely cost. That's really what it comes down to.”*

In more detail, majority of costs are comprised of personnel cost differences, which on average account for two thirds of costs (Beckmann and Fischer 1994).

Interviewee y: *“I think the cost is one important part, because the human part for the worker or colleague is lower.”*

Nevertheless, as shown in the latter quotations concerning cost, it is definitely not the decisive factor but more of a secondary issue.

Interviewee x: *“These decisions that are purely based on cost, then you have to go back and say what are the fundamentals supporting that cost structure as the fundamentals supporting a low cost supply side globalization will definitely change and there does not seem to be a recognition of this by entrants.”*

Interviewee b: *“Cost is a one factor but not only one. Cost is not an issue even though it’s very expensive cost economics is secondary issue.”*

Interviewee z: *“Ah, cost is always a consideration. In our current move, we are not driven by cost. Clearly cost is not a negative factor. I mean cost is a contributing factor but cost is not a determining factor.”*

Interviewee a: *“Now if you talk to someone, it is going to be a number of different factors and not just a one. Cost has always been there, so now it is mentioned, not anymore on the top, now it's going to be one of the factors affecting.”*

The difference in the significance of cost differentials and the way it is manifested varies between the alternative forms. In R&D offshore outsourcing it is a major push factor even though not conclusive.

Interviewee x: *“To address this [cost] major pharmaceutical companies are in a sense outsourcing their R&D or setting up essentially self-managed offshored-subsidiaries.”*

Interviewee d: *“Actually outsource is another way to improve cost-effectiveness. [...] If you outsource, this company hire from China, they will reduce costs so why we don't have our own R&D do that.”*

In R&D offshoring, cost also plays an important role, which diminishes over time as other factors become more important.

Interviewee x: *“The other way is reducing R&D costs in general, [...] the inconveniences and difficulties of long-distance offshoring start to outweigh the*

financial benefits. [...] Cost is also the ability to do more with the same money.”

Interviewee d: *“China has kind of cheap labor. So they [company] think move some high cost center to China.”*

In the case of R&D internationalization, cost is also an influencing factor. Nevertheless, benefits associated with cost do not justify this type of a long time span, multi-operational, evolutionary approach to R&D globalization. This is because R&D internationalization requires a long-term strategy and a step-by-step approach to building networks and focus on the overseas local market.

Interviewee d: *“There is right now a very large cost factor gap, between, let's say, doing your R&D in Europe and doing your R&D in China. [...] ultimately the cost factors are just standard of living cost that start to go up. [...] R&D like manufacturing requires large infrastructure investments. There is a great big building, lots of equipment, sterilization, high cost and level of training.”*

Interviewee z: *“Number one is whether you consider China is a strategic investment. That is the key point, because you don't come here to just save some money.”*

Another cost economics factor is government incentives, which for a small company can be crucial in the early life, especially in the form of infrastructure incentives.

Interviewee x: *“Places like China attract in infrastructure incentives, in monetary incentives and low cost incentives. [...] The provincial government and even the city governments are extremely active in providing financial and infrastructure incentives, which are offered to folks that establish something, not just hire a local company to do R&D but establish their own R&D operation. [...] Initial infrastructure incentives are buildings, equipment.”*

Interviewee z: *“Second reason is investment from the government for the risk investment; this is the only nation that's R&D investment for the pharmaceutical industry is growing.”*

In the case of luring multinational companies to a country, tax incentives play an important part.

Interviewee d: *“China has a very good investment environment. Government will give you some tax free. We have to buy animals, buy some chemicals and also import some medical, medicine materials, so the government will give you some tax [exemption], maybe interest free loan, maybe also no import duty.”*

Interviewee c: *“Companies can move a R&D center to China. Well they might be setting one up there due to early incentives. [...] If you build your R&D center to China they [companies] are going to get price incentives to [products] being distributed in China, which is a huge market.”*

Based on the findings cost could be corroborated as an influencing factor and it is evident in all governance forms. Nevertheless the finding by (Lewin and Peeters 2006; Norwood 2006; Davis 2000; Reddy 1997; Buckley and Casson 1976) of cost as decisive or only factor is refuted. Furthermore financial incentives as suggested by (Hu 2007; Gassman and Han 2004; Grossman and Helpman 2003; Boddewyn 1985) such as infrastructure or cash incentives, or tax subsidies are corroborated as an influencing factor.

4.1.2 Availability of advanced labor pool

When looking offshoring in more detail the following factors emerge from the literature. As depicted earlier, a major factor affecting offshoring decisions is the scarcity of advanced R&D resources in the home country. At presently, the insufficient R&D labor pool in western countries constitutes a scarce R&D resource that can be seen for example from the lack of new science and engineering graduates. Also large portion of students studying in life sciences or engineering, especially in the United States, are from overseas emerging countries like China and India. In contrast, there is a huge R&D labor pool in these countries that is further supplemented by returning students from western countries. Beckmann and Fischer (1994) see that in the Western world, especially in smaller countries there is a scarcity of engineers and researchers.

Interviewee c: *“The USA cannot find [enough] good scientists. Americans don't want to go into science and engineering and Singapore has the same problem too.”*

Interviewee z: *“I think that the greater concentration of well-trained scientist, students is one of the reasons why it is really catching on.”*

Interviewee z: *“The talent pool in China is another reason discussed, it is not superior to Western talent pool but China is catching up and in here you can hire tomorrow a hundred new scientist or graduates, which is an influencing factor.”*

Bardhan (2006) says that crucial features for R&D globalization are geographical distribution and clustering of talented labor, tradition for commitment by R&D labor as knowledge assets, labor market mobility and labor laws as well as contractual labor provisions and practices.

Interviewee c: *“Why western companies are moving to China and opening shop is cheap labor costs, more consistent labor with no unions and the number of engineers, an army of engineers and scientists that graduate every year. [...] The incentive is the labor force with no union.”*

Beckmann and Fischer (1994) also state that first and foremost importance for the success of the R&D mission is the availability of advanced R&D labor pool and the expertise of the personnel.

Interviewee d: *“[When a company] setup this R&D center maybe two three years ago basically with two or three persons but now normally they have hundreds of personnel, they hire a lot of Chinese scientists. So lot of scientists doing testing. [...] When they decide to do research, one thing they think is that the Chinese have talent to do the tests. In many overseas R&D facilities, they already have Chinese scientists and China has kind of cheap labor force.”*

Interviewee c: *“There are so many engineers and scientists, the reason why I do think, is that China cranks up like a million engineers every year, undergraduates or what you would consider university bachelors. They just have the numbers. The actual numbers of people who will do the job with little money. Quality of the actual employees, I think they are good academically, they are obedient, studious, diligent.”*

Pharmaceutical industry is highly dependent on the availability of academic personnel and expertise (Beckmann and Fischer 1994).

Interviewee y: *“There are many candidates in China that can work in the pharmaceutical sector. [...] I think the students in China are very good, they are very*

hard working and diligent. I think this is a huge advantage of China. There are a huge number of graduates from universities every year.”

Interviewee z: *“Basically in China they produce vast quantities of PhD's and master's degrees and clearly there is a huge talent pool in China, and that is another area that is becoming attractive to us. It has lot of well-trained scientists, which are ready to be employed. The Chinese university students, they are very good. The CRO company we are using, they have some of their bench scientists, they are freshly out of the Chinese education system, have a master's degree.”*

A specific case of the talent pool that is available in China is the mentioned overseas students and researchers who return to China for top research or managerial positions or to start companies, which augments the available skill pool. Amongst the input-oriented motivations for establishing R&D in China according to Gassmann and Han (2004), is the huge human resource reservoir is of great importance, which is augmented by the extremely skilled Chinese overseas students returning to China. These returning Chinese form a uniquely qualified additional human resource pool, which brings with it global experience and knowledge (Gassmann and Han 2004).

Interviewee x: *“One thing China has to offer is returning Chinese from abroad that are extremely well trained, [...] majority of students studying life sciences abroad in US, the training they get when they stay and work in the pharmaceutical industry is a very high quality and they show up [back in China] with greater sophistication and skill set. The concentration of educated labor in China is greater than in other areas. And I think that this is one of the reasons why this seems to be catching on.”*

Interviewee c: *“Chinese people who are getting educated in the top US universities, getting training and work in the US for a few years and then they go back to Asia. There is a lot of them, they want to go to the engineering and science fields and if they receive the training in the US, that's usually pretty good. [...] The people who are at the senior level are people who have been educated in the US or Europe. There is always someone who is doing all the coordinating, that you are completely relying on, like a senior scientist.”*

Interviewee d: *“They are Chinese but education from overseas. At least the senior level, they have overseas background. Maybe for some basic roles they can*

hire locals but little bit senior they hire overseas talent. So I believe our Chinese scientist also have an overseas background.”

Leifer and Triscari (1987) argue that there are increased communication requirements for research compared to development. They say that as R&D work progresses to being an operational reality that is near production approval, internal and external special interest groups become more involved and funds are required. At that point external influence on the R&D project grows and the project requires more maintainability from higher management (Leifer and Triscari 1987)

Interviewee z: *“Western companies coming to China, a very important component is whoever can communicate with their counterpart in US or Europe, a scientist who has been working in USA or Europe know more about the way people communicate in. You really have to have a core scientist trained both in China and in the Western country. [...] Little bit more senior officials, this is always happening that this person is the way they call in China, these persons are returnees. Basically they are born in China, they spend like ten years, twenty years in the United States or in Europe. They come back and they are very good in the bridging role.”*

Gassmann and Han (2004) highlight that the difficulty of attracting best international talent to overseas destinations, forces companies to establish R&D facilities to locations where highest expertise and facilities are available.

Interviewee b: *“It's true that US educated Chinese are coming back with excellent science degrees. This is a trend that lots of people like myself went back to China and bring the business and the technology. Even in the university if you look at the professor in China like in Fudan [top 5 university in China and Shanghai's leading educational institute], most of them have been training at least six months, one year in some western country.”*

Geographical distribution, clustering and abundance of advanced labor as indicated by (Bardhan 2006; Bardhan and Jaffee 2005; Gassman and von Zedtwitz 1999; Gerybache and Reeger 1999; Beckmann and Fischer 1994; Boddewyn 1985) was corroborated according to author's findings, especially the huge R&D labor pool of graduate scientist and engineers in China reported by (Gassman and Han 2004).

Similarly the author can corroborate the insufficient R&D labor pool in western countries, which constitutes a scarce R&D resource that is an influencing factor in R&D intensive sectors, such as the pharmaceutical industry (Gassman and Han 2004; Gassman and von Zedtwitz 1999; Beckmann and Fischer 1994; Boddewyn 1985). Fur-

thermore the author can corroborate the influence of returning Chinese students from western countries, which supplements the Chinese labor pool with advanced capabilities as indicated by (Gassmann and Han 2004; von Zedtwitz and Gassman 2002).

Access to local science and technology could neither be corroborated fully nor refuted, especially in the sense indicated by von Zedtwitz and Gassmann (2002) in their technology-driven model or by Gassman and Han (2004) as pull factor from high rate of new technology output. Nevertheless, it can be seen to refer to accessing the huge advanced labor pool in countries like China and thus to be corroborated.

A labor implication highlighted by Bardhan (2006) on commitment by R&D labor as knowledge assets, labor market mobility and labor laws as well as contractual labor provisions and practices could not be corroborated or refuted even though strongly implied, due to the limited focus of the empirical data in this study.

4.1.3 *Centers of excellence*

Another factor affecting R&D globalization decisions are the spill-over effects from local investment to science, technology and advanced infrastructure, together with the environment they create. These investments are usually done in Science parks, universities or technology and science clusters that form centers of excellence. These centers of excellence attract investment from the industry and both local, overseas and multinational companies.

Interviewee t: *“The (R&D) resources are mostly concentrated in Beijing, Guangzhou and Shanghai. Some main platforms were used for highly effective researches, such kind of platforms to conduct R&D. [...] In this way we make a perfect match. With their help, they [pharmaceutical companies] do not have to build their own R&D centers or teams.”*

Interviewee b: *“Like [major pharmaceutical company] has a R&D center, you know the area Zhangjiang high tech, it’s in Pudong. In Zhangjiang it’s a lot of foreign companies R&D center there.”*

Interviewee z: *“The expertise factor is another thing, probably more important than the cost factor, because in our business, sometimes time or speed is even more important than the cost.”*

Beckmann and Fischer (1994) argue that private facilities as well as public institutions, such as research centers and universities, function as local sources of engineering and natural science knowledge along with technical spill-over.

Interviewee b: *“We have quite a number of collaborations with the Fudan University. In the developing countries we can only work with a small number of professionals, universities. [Major pharmaceutical company], my department, has three contracts with Fudan University, we sponsor the faculties, we help the Fudan medical school and twice a year in China we sponsor the large scale workshop to develop the next generation of healthcare policy and research. Also we have other research projects with Beijing University and Tongji University and some specific projects together with local Shanghainese companies. I think the best thing to consider is not to develop a new lab in China, but the best approach or strategy is to partner up with the university in China, to collaborate with Chinese universities or local companies.”*

Interviewee y: *“The researching ability of Chinese universities, research centers or hospitals differ greatly. It depends on the ability of each site. And if you choose carefully a very professional site, with a strong advantage, you can get very good results. Some famous universities and research institutions are quite reliable. There are about two or three laboratory companies that are quite famous with lot of people. [...] When choosing the site I think more work should be done to lower the risks.”*

Another factor corroborated in this study is centers of excellence, which are usually in conjunction with science parks, universities or technology and science clusters (Gassman and Han 2004; von Zedtwitz and Gassman 2002; Gerybazhe and Reeger 1999; Beckmann and Fischer 1994; Boddewyn 1985). Centers of excellence benefit companies through spill-over effects from local investment to science, technology and advanced infrastructure (Beckmann and Fischer 1994). Centers of excellence also often host experts and specialists in particular fields who may benefit companies through easy access to leading scientific researchers and networks (Boddewyn 1985).

These specialists and the centers of excellence are usually dependant on public financing, thus their focus and research in general is shaped by the national innovation system in the country, which is a macro level factor corroborated in this study as outlined by (Gerybazhe and Reeger 1999; Boddewyn 1985).

As said, access to local science and technology could neither be corroborated fully nor refuted, especially in the sense indicated by von Zedtwitz and Gassmann (2002) in their technology-driven model or by Gassman and Han (2004) as pull factor from high rate of new technology output. It can nevertheless refer to expertise present in centers of excellence and individual experts and hence corroborated. But in the case of China the

cutting edge science, technological breakthroughs and pharmaceutical innovation are still lacking.

4.1.4 Access to markets, local adaptation

Market considerations seem to weight most when companies seek R&D internationalization. The growing importance of emerging markets such as China pulls more and more advanced corporate functions when conditions are appropriate for them in the host country.

Interviewee d: *“For the multinational company like Pfizer, Clensay, GSK they have to, we have to be in China. Next question is why? Because the growth rate is much higher. I think no one can ignore China. So that's why the reason we want to do R&D in the developing country [China]. [...] Everyone is waiting on the market. [...] The reason is the market trend, not the cost of development. There are other countries that can do very cheap but there is no market. In China there is an economic boom. Right that's in China, a huge market that no big company can ignore. [...] A lot of foreign companies establish R&D centers for the reason because they want to get in to the Asia [Chinese market], establish a lab in. That's the trend. This is why a number of R&D centers have been established.”*

Interviewee t: *“Some companies only concentrate on sales. They buy product lines and licenses from other companies and produce and sell the products through their own sales channels and networks. In this way they make profits. From the viewpoint of the Chinese market, the goal of R&D is to make profit. Even though some companies concentrate on developing medicine for certain kind of diseases, they would evaluate the market for the medicine at first. This is to say, that R&D in China is market oriented.”*

One of the main reasons for constructing technical research abroad is the difficulties in receiving permits from local institutions.

Interviewee c: *“Automatically company still need to get to the market in China, therefore they need to have a presence there, so move over an R&D center.”*

Market potential, i.e. market size and growth, is especially paramount in regards to company's interest in placing R&D opposed to lower value operations to that specific country (Beckmann and Fischer 1994). To gain long term competitive edge companies

have to make strategic investments and attain market share in tomorrow's biggest markets.

Interviewee z: *“Reason one, is that China becomes the next pharmaceutical market. For pharmaceutical industry, research R&D is co-parallel with the commercial development. [...] Yes, because China is the next pharmaceutical market, so R&D has to follow up. [...] I would say that the market potential is bigger than the cost. [...] You consider China is a strategic investment. [...] The discussions are centered on the potentials because China will be the second largest pharmaceutical market.”*

Interviewee d: *“We are informed from our headquarters they want to invest in this R&D center and they think that China is very high potential. [...] Our Company always say we want to invest in China. We look at China's good potential, so we move some R&D center to China. So this is our long term strategy.”*

Interviewee y: *“Decisions on expanding may be dependent on marketing and marketing department. It is their decision, because China is a really huge market for the drug companies and maybe quite many decisions on research is depending on sales and marketing.”*

Interviewee t: *“market analysis, market development, sales including presales, during sales and after sales services [...] We collect information for R&D department and market department. And they do analysis and developments based on our information.”*

In the pharmaceutical industry market access basically requires the conduct of foreign R&D in the target market, chiefly the replication of studies for pharmaceutical registration (Granstrand, Håkanson and Sjölander 1993). Beckmann and Fischer (1994) also state that a pre-requirement for introduction of pharma products is their applicability to local legal requirements and pharmacopoeia standards (China pharmacopoeia commission 2005).

Interviewee y: *“So that the product can be on the market in China is based on the legal requirements of SFDA, which is the overseeing authority in China. You need to hand over the necessary documents to apply to market in China. That is the most important document.”*

Interviewee d: *“To get an approval of China food and drug administration (CFDA, SFDA) for the more multinational company like Pfizer, Clensay, GSK have to, we have to be in China.”*

Interviewee t: *“the R&D procedure in China is different from that in foreign countries. In foreign countries they develop new medicines according to their criteria. When the products are mature [...] they adapt the equipment according to characteristics of local people. And these adaptations could be conducted in China.”*

The decisive influencing factor corroborated in this study is access to markets as reported by (Grossman and Hansberg 2006;2008; Bardhan 2006; von Zedtwitz and Gassman 2002; Gerybazhe and Reeger 1999; Beckmann and Fischer 1994). Especially the size of the Chinese market and growth rate is an influencing factor, most emphasized on a long term strategy of Big Pharma companies but also of importance to small and medium sized companies. The growing importance of emerging markets such as China pulls more and more value-added corporate functions to the target country.

4.1.5 Local requirements and government regulations

Government regulations and requirements are a direct way to guide market interest. In the sense of R&D, governments capitalize on markets interest through requirements for locating R&D to the country in question. Thus in exchange for a marketing permission, governments require research to be conducted in the country and according to local standards and requirements. On top of boosting the local industry and creating jobs, locally conducted R&D may also involve involuntary one way technology transfer. In the pharmaceutical industry, importance of government regulations and requirements are highly pronounced even though they are dependent on markets in many accounts.

Interviewee d: *“If we want to sell product in China we have to do some deals with the government. The Government, what they want to do is to develop China. If we are very focused on our patenting we don't care business in China.”*

Interviewee c: *“For exporters China wants to do compulsory licensing.”*

Interviewee a: *“They [the pharmaceutical industry] is late in internationalization of R&D because they are very IP sensitive. Generally speaking, the whole IP [intellectual property], medical research and development, drugs,*

hospitals, hospital services, medical services is extremely regulated in China so it is very difficult to do what they need to do.”

Beckmann and Fischer (1994) explain that acquiring permits from local institutions is one of the biggest obstacles for conducting technical research abroad and the application times can total several years. Furthermore especially in China the process requires wide open disclosure and cooperation with stakeholders.

Interviewee y: *“I think the Chinese government regulations is the weak area. I mean SFDA, like Sino food and drug administration, they really don't have the experience to approve like first in class drug, I mean in China, I think they normally do like, the drug has been marketed in the Western world and they launch in China. So they have a lot of precedent to look for. [...] So the drug has been approved in the Western world and then come to China. [...] In China I think that the regulatory is much stricter than in Western world. It takes much longer time. [...] This is because the agency does not have the experience, so they basically very cautions. I mean they basically use the model ‘do no wrong’.”*

Interviewee y: *“Benefits [from pharmaceutical R&D] in China maybe is that the application for the active compound maybe a little easier for the Chinese overseeing authority to audit. [...] Compared to doing it in another country maybe no more extra work is needed. Maybe the laboratory work is carried out in US and material submitted to SFDA, they may ask the companies to carry out similar laboratory work in China to observe the results and procedures.”*

Interviewee d: *“A specific government regulation issue on vaccination is the CDC. CDC is owned by the government, so when they have some health problem to vaccinate, the whole CDC maybe will focus on this vaccination and not on others. There is no continuation, that will impact our sales, that's not stable and it's a very hard to get a forecast and then our production will have difficult to do the production.”*

Due to historic reasons the Chinese regulatory environment is extremely nervous when it comes to medicines not previously approved in other parts of the world (Shah 2003). For this reason two different approval channels for drugs exist, one for those already tested according to FDA or EMA specifications and another one for those drugs that see their first clinical trials in China.

Interviewee b: *“In China FDA or EMA approval is a good start. If a product is totally new, it has not been approved in any other country in the world, then they have to go through the rougher parts. Most of the product is always developed in the western world first and then move to China. The regulatory approval, ADN approval right now the process in China is much longer, about six months longer than in other countries.”*

Safety measures and standards are sometimes used both in the developed countries but even more so in developing countries like China to facilitate technology transfer and increase investment to the target country. Identically as reported by (Boddewyn 1985) companies were pressured to participate in developing European Community (EC) standards, which increased investment by U.S. and non-European multinationals to European subsidiaries.

Interviewee d: *“In China the registration environment is important for a pharmaceutical company to exist. [...] Pharmacopeia was updated from last year and they improved many standards and these standards are for GSK, Pasteur, for this kind of multinational company these standards are very hard to meet, but our local company claims that they can do that so, kind of protection, government protection, the issue they updated the pharmacopeia.”*

Interviewee t: *“[Government policy influences medicine] currently very much. That is the current system in China. For example in 2009, [major pharmaceutical company] as one of the biggest foreign companies in China in terms of baby vaccine lost its whole production line because of government intervention to protect domestic producers.”*

Interviewee d: *“So we have several products affected which cannot meet these standards. Our team should register products accordingly and sometimes have to change our core production biotechnology to meet the standards. [...]The standard is ridiculous, because US and EU they all accept our [company's] very high standard, so China ask kind of higher standard. [...] So this kind of product can never be sold in China.”*

Interviewee d: *“If your product cannot meet [government] standards, but if you want to license your product in China, bring your technology to China, maybe you can discuss with the government in that five years if your product still exist in China. So after five years we already put our technology to China to produce locally so you can produce. During this five years, this*

transmission period you can give you some temporary import license and you can sell the imported product but you have to quarantine you take technologies into China. [...] There are some dangers to this but have to discuss with the government but if you want to continue sell this kind of product in China you have to do some deals with the government. Government use these kind of ways to persuade multinational company to work with them.”

According to this study the author corroborates the importance of receiving permits from local institutions and the difficulties in fulfilling local requirements and standards as an influencing factor as reported by (Grossman and Hansberg 2006;2008; Gassman and Han 2004; von Zedtwitz and Gassman 2002; Beckmann and Fischer 1994). Access to local science and technology could neither be corroborated fully nor refuted, especially in the sense indicated by von Zedtwitz and Gassmann (2002) in their technology-driven model or by Gassman and Han (2004) as pull factor from high rate of new technology output. Nevertheless, it can be corroborated in a wider sense through the importance of corresponding to local technology standards and requirements, most notably the Chinese pharmacopoeia standards.

4.1.6 Risk factors

Issues dealing with intellectual property rights (IP) present a challenging case in China. IP issues seem to have been an influencing factor in earlier research on R&D globalization. However, due to improvements in international IP standards, the nature of IP and the problems associated with it, seem to have changed. Also surprising and contrary to layman's view of IP protection in China is the improved state of patent protection and formal codified IP protection.

Interviewee a: *“This is also a matter of IP, how IP has developed, because you don't outsource unless you have some legal safety net behind it. For China [in the past] this has not been the case”*

Interviewee c: *“Even though, people think that China is Weak on their patent law and IP, which they sort of are and sort of are not depending on how you bias it. [...]What you need to see is companies need to get into China and one of the reasons is to protect their IP. [...] Kind of weird that they do it by setting an R&D center in there [China]with Chinese people like their employees but that is a one way for them to set their IP instead of just piling it from home country with having no connection with China.”*

Von Zedtwitz (2004) admits that in China intellectual property issues are understandably of concern particularly for non-public-domain innovation activities.

Interviewee x: *“So you have to be very careful when you operate in a system like this, if you establish your company under the influence that you can go to court and enforce your right you better make sure that you can, because if someone walks out of the door with your technology you may not be able to do anything about it. That's always a risk but in China you have an added risk that the court system does not follow the rules that you understand. Even if you are told of your rights or ownership you won't learn it until you try to enforce it in court.”*

However, due to improvements in international IP standards, the state of patent protection and formal codified IP protection has improved substantially.

Interviewee z: *“I think IP protection is fine. Because like five years ago everyone was after IP but right now nobody talks about IP. Because basically everybody knows, what everybody else is doing. And because right now what will be the best topic to work on, so you know, I mean right now IP is not that issue because get IP[a patent] though everybody knows what you are doing it will not be easy to mimic you. In pharmaceutical research even you know what other people are doing, you want to come up with a different compound, slightly better and that's a huge investment. [...] Even though you would tell me, I might be skeptical and that way you have no incentive to hide from me. [...] In pharmaceuticals even though you know what people are doing you many not just want to copy because you don't know if that is the right process and they are common knowledge. Nobody have a patent on the processes. [...] So basically that cancels out everything that doesn't need to be super classified or patented knowledge.”*

According to Li and Zhong (2003) a credible and effective intellectual property protection regime is one of the most important conditions for international and domestic R&D investment. A system that has seen some progress after China's entry into the WTO but still suffers from a cultural contradiction.

Interviewee c: *“They [Chinese] really are not into intellectual property that much, because they are not developing drugs themselves. [...] I don't think they can do IP, because of their culture they just won't report any crimes, no one will take blame. [...] Sometimes they are hiding something because*

they are stealing it [IP] from other people. [...] I have had some instances where the work they supposedly patented was published by somebody else like a year earlier and we found it in our search. That's a problem, it's a cultural thing."

There is insufficient understanding of the Chinese legal environment and business practices, such as suitable composition of senior management and distribution of decision making power. Although some issues on IP have improved, China's legal protection on uncodified IP, such as on trade secrets and proprietary technology still presents a challenge to both small and large companies.

Interviewee x: *"The IP risk you are running in China really depends on how much of your senior research management structure you put in China. You take example [major pharmaceutical company], they are putting their entire research division in China, that's a much higher risk. If your senior research makers are still back in your home country you have a much lower risk."*

Interviewee x: *"The major pharmaceutical companies when they first showed up in China, they did what typical foreign firm would do and that is they hired locally very sophisticated business development people to do deals. [...] You hire a local that's well connected and sophisticated to do your deals [with company resources], well those people did deals that benefited themselves but didn't necessary benefit the corporation. [...] Corporations like [major pharmaceutical company] swap out Chinese decisions makers every few years and replace [businessmen] with little less sophisticated, little more technical management, and all the decision making and the ability to approve and negotiate deals was taken back to HQ."*

Interviewee y: *"Physicians in China are very responsible and the results should be trusted, should be real and reliable. [...] I think the procedures are very established and professional."*

Another IP concern in China is the potential for unintended technology transfer that can foster a new competitor as reported by Boddewyn (1985).

Interviewee x: *"[Chinese] are very interested in manufacturing technology. [...] Actually the knowledge left behind in R&D, especially manufacturing development, they could try to produce a competing company depending on the level of sophistication of management you left behind. [...] Any time you*

let it [R&D] go offshore you run a risk of technology walking out of the back door. [...] If you keep your key decision makers out of China and you don't train on the D part of R&D you are in a much safer position.”

Interviewee x: *“When [...] approaching smaller pharmaceutical companies on licensing to China. They are extremely reluctant because of the risks, and yet you see the bigger pharmaceutical companies just marching in and they don't see it, it's interesting the bigger pharmaceutical companies don't see Yahoo [internet search engine] and Alibaba [Chinese B2B online marketplace] as danger, because they are doing the same kind of deals, and they are walking right into the same situation, you can call it a trap.”*

Interviewee d: *“Multinational companies they don't trust in China because the patenting issue. If you got a patent, you know Chinese sometimes [infringe] copyright [IP], maybe they leak to other competitor and then the local manufacturer will copy these medicines and sell to the hospitals. All multinational companies spend lot of money to protect IP in China.”*

Safeguarding core technologies, such as production processes is extremely important but at the same time very challenging in China.

Interviewee x: *“Everyone gets trained that patents and intellectual property is how you maintain control of your product. In China that is somewhat but not really true. The true control of your product is the knowhow how to manufacture it. So if you want to control your product, you'll got to control the ability to manufacture it. [...] What you find with Chinese companies is that they are somewhat interested in patent licenses, but they are very interested in manufacturing technology.”*

Interviewee d: *“Production technology is very special, which is not maybe patentable but is knowledge how to produce. [...] We focus on the technical, this type of technology has many hundreds of processes. [...] Local Chinese technology is not that good. [...] So they are very interested. [...] Different products have different technology. The not technical product, we buy a local company or bring the production technology into China. [...] But the product is very popular and not technical.”*

Some factors could not be given confirmation in this study, but are either partially corroborated or refuted. IP risks seem to have been an influencing factor in earlier research on R&D globalization. However, due to improvements in international IP stand-

ards the state of patent protection and formal codified IP protection has improved substantially. Similarly the author can corroborate a cultural IP find by Li and Zhong (2003), which points to a cultural contradiction between the concept of intellectual property and the Chinese society. The nature of IP and the problems associated with it seem to have changed, especially important is the safeguarding of manufacturing technology and trade secrets. Irrevocably IP risk as an affecting factor reported by (von Zedtwitz 2004; Lewin and Peeters 2006) is refuted, nevertheless IP as an conditional factor as reported by Boddewyn 1985 can be corroborated.

4.1.7 Basic conditions for R&D

When looking at the IP issues, we can see that, with the improvements in international patenting laws, the codified IP can be reasonably well protected and investment in it as well as on other security practices can be considered as necessary infrastructure for doing business in China. In the literature infrastructure is presented as a requirement for R&D globalization (Beckmann and Fischer 1994; Boddewyn 1985).

Interviewee z: *“We have some outsourcing in India but right now we set up the Asia research center in China, because we can see that China has like the basic thing, a much better infrastructure.[...] China is pretty good in certain infrastructures. And they can do certain like, right now they are doing some components work.”*

Interviewee x: *“They have the fundamentals of technology, the basics of infrastructure. But your problems are going to be purely the infrastructure of the country. Are you getting electricity? You know, the fundamentals of the country are going to collapse. You already have a huge electrical problem here. Blackouts rolling through the industrial sector costing tremendous amounts of money, because they can't simply produce enough electricity.”*

Interviewee d: *“[The infrastructure] is very difficult for the supply chain.”*

Interviewee b: *“The challenge compared to the Western countries is that we have much less expertise in China and much less data sources like FDA database, DMA electronic medical record database, patient registry. In the devel-*

oping country we have tons of [official] data and lots of CRO's and other firms to help us, in China we don't have any of those."

From the interviews conducted the author has gained an understanding that well-functioning infrastructure is a necessity for R&D globalization but instead of a pull factor it can be corroborated as conditional factor as described by Boddewyn (1985).

4.2 Pharmaceutical Drug Discovery

An unexpected factor in the case of pharmaceutical industry, a one not covered in academic literature on R&D globalization, which emerged from the research was the effect of the phase of drug development pipeline in pharmaceutical R&D.

Interviewee b: *"Talking about the pharmaceutical and medical research and development. Because there is so many different types of R&D, it could be medical clinical, pharmacokinetics as well as the post marketing research [post-marketing clinical research, phase 4]."*

Interviewee y: *"In terms of operations that is, something you do in US, something Europe, something in China. We want to do as our quest speaker said, to find the natural thing in that country. [...] Identify like where ever they have strengths. [...] We try to do the natural thing, which is the best thing we can do in China and then I want to find out what is the best thing to do in US and everywhere else and then assemble a global team. That will be the winning formula."*

It is evident that pharmaceutical R&D has to be scrutinized as a continuum of different R&D processes, which all have unique requirements and benefit from different factors. Thus it is of extreme importance that the phase of pharmaceutical R&D is considered when making decisions on globalization of R&D and the factor derived benefits are weighted in the light of R&D requirements. From the research the author was able to decipher how the phase dependent actual R&D operations affect the way pharmaceutical R&D could be beneficial to conduct in PRC and how different factors on R&D globalization can be capitalized on, when taking into account the phase in question.

Interviewee x: *"It's difficult to get an R&D system in China to be certified by the regulatory authorities in Europe and in America. Now that means that the R&D becomes much more early stage and it's a cheap way to decide*

which molecules you want to take back to your own country and start running them through the approved, certified locations. [Also the risks are lower] if you are just doing screening of molecules [leads, hit to lead], producing data and shipping that data over the internet to Europe and reviewing that data for research candidates for moving forward [lead development or pre-clinical]. [...] Few years ago it was difficult to find a certified preclinical development so it was very basic R&D that was being offered. In the last three years that's changed. A lot more firms in the bigger cities like Shanghai and Beijing are getting FDA, EMA certifications.”

Interviewee b: *“Normally multinational company they will have some R&D center in China. But as far as I'm concerned, knowing their opinions, they will do some basic research on chemistry [pre-discovery, hit to lead]. They are doing pharmaceutical tests but it is really beginning stage. [...] Phase one, mean pre-discovery and discovery. It should be very first part, they are doing really big research and when they find out some good results they send them to overseas labs where they will think if these results are useful for the development. [...] Like in China you just focus on the basic work, maybe England phase two, maybe this country phase three. [...] We have number of R&D center around the world but we in China take responsibility of some of this basic work.”*

Interviewee c: *“In the development there are certain times when you have to do the same process over and over. I mean tasting phase. [...] Discovery and testing. [...] Asian scientist: They are the ones doing just the testing. [...] They certainly have the knowhow but they don't have the inventiveness, the creativity. [...] When it comes to creating things I have a hard time dealing with inventors in Asia. They are just not very good at interpreting their results.”*

Interviewee z: *“For example like the chemical synthesis, like the chemistry. [...] It is the chemistry, the making of compounds that's a potential drug. And in China they do that well. [...] It's before hit-to-lead. Well hit to lead is part of the compound finding. So hit-to-lead is also a part of it. [...] Hit-to-lead is part of the compound finding, you have some hit, those are what we call scaffolds. They may not be potent enough as clinical drug so you want to make some changes. Hit is normally referred to that you have done screening, where you see lots of scaffolds and this is potential. Then you have to refine to make that hit into a lead compound. This area they do really well in China, but hit to lead is not just chemistry because you*

need biological agent for screening and in that [part, they do not excel in China] in chemistry part they excel. [...] China has strengths in the hit-to-lead and we try to capitalize in those strengths. [...] The lead development part is also fine, basically even you identify a lead, there is still a lot of chemistry involved. [...] In terms of chemistry, most of the pharmaceutical companies have a presence in China doing the chemistry part.”

Interviewee z: *“Most of time pharmaceutical company doing the chemistry part in China and once it has reached the late stage like preclinical or clinical they often move back to the US or Europe. [...] Biology and toxicology, I think that combination is still little bit lacking. [...] But our company come to China and says we want to do the more innovative side. I mean that's an area we want to expand.”*

Interviewee y: *“I think it [pharmaceutical R&D in China] includes some like office work, maybe something like data mining. [...] Work people can do in office can also be transferred to China.”*

Interviewee x: *“In China it's more of a preclinical and the reason is that Chinese are very rightfully quite concerned, about clinical development of molecules that have not experienced clinical development outside of China. [...] The Chinese were treated like guinea pigs for clinical trials for a period of time and they are discouraging for clinical trials for foreign firms where there is no clinical experience outside China.”*

Interviewee x: *“Approval in China is independent from other countries but if you have it [FDA or EMA approval], if the drug has not experienced approval outside of China you will get much more slow and cumbersome process.”*

Interviewee y: *“Conducting clinical trials in China has real benefits. Procedures are very professional and very established. [...] Clinical trials maybe 1, 2, 3 can be transferred to China. [...] Any part of clinical trials could be beneficial to be held in China. [...] Clinical trials can involve hospitals in China, establish a few sites in a big country to enroll patients with [rare] specific conditions, for example China has big population. [...] I think that China has quite a large number of patients to can be enrolled to specific research in China, I think these are important aspects. [...] The patients in China are a huge amount and to the disease that is hard to enroll patients in other countries maybe is ok in China.”*

Interviewee d: *“Basically we have some phase 1, 2, 3 medicine, doing clinical reporting in China. China have a very big pool, many different patients and they can take these clinical tests and we get results. [...] Clinical test we should do in China, if we have some clinical test in overseas it takes a long time and very complicated just to receive license. [...] So when we have a new product to launch in China, the very big barrier is just this clinical. We may take five or six years to finish this phase. [...] If we have an approval from overseas then [in China] we need to do [only] phase three or [after market approval] phase 4.”*

Interviewee b: *“I think that in the past patients [in clinical trials] is thirty percent of the cost but now is like forty to fifty percent. The reason we like to include the patient for the clinical research in developing countries, for example in China is that it's much cheaper. The difference is getting smaller and right now when we include the patients in China is it's getting more and more expensive although it's still cheaper than in the US. [...] [The clinical trials] in China have been more and more formalized and they require at least two hundred patients for each product and each indication. [...] More and more companies do international trials, we call it a global trial. We will recruit patients from many countries, not just one country. China is a hurdle because it takes much more time to get an approval in China, so the whole study time is getting longer. And the US FDA still has concerns about the research project conducted in a country like China.”*

As expressed by the author as part of the initial framework that different phases of drug development require different competencies and have distinctive benefits, this view was confirmed in the empirical research conducted for this paper. The cost emphasis plays a part in the earlier phases as personnel costs make up the bulk, a case which is almost synonymous with offshoring to China. It is also on these early phases where IP risks are most negligible and the IP structure of PRC is less of a concern. Another factor speaking on the behalf of this, is the insurmountable amount of advanced labor resources in PRC. This would suggest that early R&D on drug development can be beneficial to conduct in PRC through offshoring or outsourcing. Similarly as a home to thousands of engineers and scientists, China has a patient population, which is greater than in any other country in the world and relatively native to wide medicine usage contrary to West. This taken together, with the emphasis on the market and strict enforcement of the Chinese pharmacopoeia standard, suggest that clinical trials of drugs that target the Chinese market or global trials would be beneficial to conduct in the PRC. Aiming for

the market, especially for the bigger pharmaceutical companies requires an extensive and long term strategic investment best achieved through R&D internationalization.

4.3 Different Governance Forms for Globalization of R&D

To answer the questions posted in this study, the clout of each individual mode of global R&D globalization and the relationships between them on the whole pharmaceutical R&D globalization was examined.

Interviewee d: *“This is very new in China. [...] [Pharmaceutical R&D on this scale has been going on] just two or three years in China. I heard they [company] have hundreds of projects in China. [...] It’s a long term [strategy], I don’t think in these years our R&D centers do not get perfect, because it takes lot of time.”*

Interviewee x: *“The biggest pharmaceutical companies are offshoring and the smaller pharmaceutical companies are outsourcing. [...] I think the vast majority of it is offshoring.”*

Interviewee t: *“[Company] doesn’t outsource its R&D. We do R&D on our own. [Company] has bought a domestic [Chinese] pharmaceutical company whole line of R&D, production and sales and it’s R&D is mainly domestic [Chinese] based.”*

Interviewee b: *“For the pharmaceutical industry, any large companies like Jonhson and Johnson GSK, Pfizer, AstraZenega, Merc, Eli Lilly, you can see they all developed a R&D center in China.”*

The interviews would suggest that R&D globalization has first been cost driven manufacturing development that has expanded and begun to service the Chinese market. The focus on the Chinese market seen in the interviews below and the importance placed on accessing the market as a factor on R&D globalization would suggest that for many companies this is an evolutionary process of the firms overall internationalization and continued presence in the Chinese market.

Interviewee y: *“Now the functions in our R&D center are expanding, this means that more work will be transferred to China. [...] Some back office work is established as a first step and maybe further steps can then be conducted in*

China." Further decisions on expanding maybe dependent on marketing and the marketing department."

Interviewee a: *"First it has been cost-driven offshoring, now they [companies] are getting more and more to [offshore outsourcing]. [...] This really is also the continuation of the overall internationalization of the firm. [...] I think that China has been production, then sales and then R&D. And I think the theory would say that it is first sales, then production so that's what I think."*

Interviewee b: *"The decisions will be made on different levels, it could be the CEO, we have a senior leadership team, it's called a board of trust, in every meeting, I think about eighty percent of time they are discussing about [the market in]China. [...] More and more technology has been transferred to China from Western Europe and US. Because of the more and more internationalized R&D, more research and the technology can be found [in China] and the research capability can be in the developing country."*

In the case of China, this internationalization can be said to be the result of the invisible hand of the markets, where the decades spend as the world's factory and the wealth created have transformed China into a lucrative market, increasingly attracting higher value chain activities due to its market potential.

Lately pharmaceutical R&D has started to rely on Chinese outsourcing companies and begun to service the Chinese market instead of improving the manufacturing or augmenting the products sold at home market.

Interviewee a: *"I think initially it has been cost-driven offshoring of R&D, in-house offshoring. Only now that local Chinese firms are getting better and better, I think that foreign firms are getting more and more towards working with the Chinese companies. [...] I think India has been quicker doing this, industry is basically offering themselves as outsourced services, not offshored services. [...] Two things [IP and culture] have held back China, so China has been late in offshore outsourcing"*

Interviewee y: *"Cooperation with CRO companies that means transferring some work to them. [...] This kind of transfer can save money and a lot of energy. [...] This kind of work is temporary, which means company doesn't need to recruit more scientist for a temporary work."*

Interviewee x: *“Chinese have a number of things to offer to folks who think that outsourcing R&D is a good idea [...] I would say that outsourcing in any specific sector works pretty decently in the beginning.”*

Interviewee d: *“Some, not that big company, pharmaceutical company, they will work with outsourcing companies. [...] Or they will work together [with a Chinese company] to make some R&D research. [...] [A good] outsource company is also very hard to find. We have to do lot of research to identify if they are qualified.”*

Interviewee b: *“For our company that is, we started the subsidiary because there is a lot of Chinese CRO [contract research organizations] companies and they can provide a very efficient service for us.”*

Access to local science and technology could neither be corroborated fully nor refuted, especially in the sense indicated by von Zedtwitz and Gassmann (2002) in their technology-driven model or by Gassman and Han (2004) as pull factor from high rate of new technology output. Concerning small or medium sized pharmaceutical companies, access to local science and technology can also refer to the flexible access to local CRO and CMO companies, their expertise and capabilities, an empirically corroborated finding. Taken together with the flexible access to Chinese CROs and CMOs and their government approved processes, these factors present a convincing argument for smaller pharmaceutical companies to engage in a multitude of different sourcing and cooperation activities with these Chinese service providers.

5 DISCUSSION AND CONCLUSIONS

5.1 Theoretical Contributions

Multiple reasons for globalization of R&D exist and firms seek to capitalize on those factors that further their competitive advantages (Kuemmerle 1999). As companies have different reasons and pursue different benefits from the globalization of R&D (Kuemmerle 1999), they also use different methods to capitalize on these influencing factors. Companies can be divided into different types and sizes based on what they seek from the globalization of R&D and through what means (von Zedtwitz and Gassmann 2002; Gerybadze and Reger 1999; Ronstadt 1978). Kuemmerle's (1999) division on company's overseas R&D operations to either home-base-augmenting (HBA) or home-base-exploiting (HBE) draws a clear distinction, whether company's R&D and products are meant for their home and conventional market or meant for a new market in the target country.

The author has shown in this paper that companies can be divided based on the governance forms utilized in R&D globalization. These governance forms for R&D globalization according to Boehe (2008) are: offshoring of R&D, offshore outsourcing of R&D and internationalization of R&D (cf. Ronstadt 1977). Similarly the author has highlighted how distinct influencing factor derived benefits can be capitalized on depending, which governance form company utilizes in R&D globalization. Furthermore in this paper the author has argued that the distinction to home-base-augmenting (HBA) or home-base-exploiting (HBE) firms to be fundamental in any decisions regarding R&D globalization and has shown the distinction to be an important determinant in choosing between strategic long term commitment to target market through R&D internationalization and between other R&D globalization governance forms.

The growing importance of emerging markets such as China pulls more and more advanced corporate functions when conditions are appropriate for them in the host country. Market considerations seem to weight most when companies seek R&D internationalization, with market potential, i.e. market size and growth being especially paramount in regards to company's interest in placing R&D opposed to lower value operations to a specific country (Beckmann and Fischer 1994). To gain long term competitive edge companies have to make strategic investments and attain market share in tomorrow's biggest markets. The author has shown that focusing on the pharmaceutical market and following government regulations in PRC requires a long term strategic commitment, multiple business functions from logistics and marketing to local R&D, with especially important the conduct of clinical trials according to the Chinese pharmacopoeia (China Pharmacopoeia Committee 2005).

Market access was also important determinant in von Zedtwitz and Gassmann (2002) classification of company's involvement in foreign R&D, which divided factors as those related to access to markets and customers or those related to access to local science and technology. According to the empirical findings in the case of China, access to local science and technology has less to do with accessing cutting edge science, technological breakthroughs or pharmaceutical innovation and more to do with the importance of corresponding to local technology standards and requirements, accessing the huge advanced labor pool and expertise present in centers of excellence and individual experts, which are all factors mostly influencing offshoring of R&D. Previously offshored production or acquisition of local production technology has shown to be a pull factor and influencing R&D offshoring as the preferred governance form. Another factor influencing R&D offshoring are government incentives on infrastructure, technology or as financial benefits, which by themselves cannot validate wider involvement in the market but are out of reach if offshore outsourcing is preferred.

Although cost considerations are shown to be a factor in all governance forms, based on this study it is evident that they aren't and shouldn't be a decisive factor. This except when dealing with operations that can be securely and beneficially offshore outsourced to gain access to local service providers, to gain country intelligence and to support initial market entry through collaboration, which are all factors influencing offshore outsourcing decisions. Indeed lately the Chinese CMO, CRO industry has become more formidable and pharmaceutical R&D, which either services the Chinese or overseas US or European markets has started to rely on Chinese outsourcing companies. Thusly cost consideration can be a major factor for offshore outsourcing if it is determined that all other factor derived benefits of interest can be capitalized by the firm this way and further significant influencing factor derived benefits cannot be gained with the establishment of in-house operations through R&D offshoring.

Cost can play a factor in more IP sensitive parts of drug discovery if offshoring is advisable due to insurmountable labor costs even thou in-house involvement would not be required for market, labor or technology access reasons.

Furthermore cost together with other macroeconomic factors can also influence R&D internationalization when weighted against the market potential. Although other factors have greater influence as R&D internationalization requires a long-term strategy and a step-by-step approach to building networks and focus on the overseas local market and thusly any cost advantages could only be capitalized after a period of time and after an upfront financial risk. Generally speaking when establishing permanent facilities and operations that target the host country cost factor should be overruled as secondary issue in favor of market considerations, labor considerations or access to science or technology through centers of excellence.

In the light of author's empirical findings and literature review some factors could be corroborated, others partially corroborated while some were refuted on a theoretical

level, within the limitations of this study following the theories of Popper (1972) on knowledge accumulation by conjectures and refutations.

Theoretical contributions were achieved by corroborating literature findings on: conditional factors, regional market requirements, local legal requirements, centers of excellence, national innovation system, cross-country cost differentials, financial incentives, access to advanced labor pool, scarce R&D resources at home and access to markets. The corroborated factors provide theoretical meaning together with author partially supporting literature findings on: convergence of patent standards, IP protection, data security, cultural IP issues, access to local technology, while refuting findings on: high rate of new technology output, communication risk and institutional or codified IP risk. The theoretical contributions presented by the author are that majority of literature derived factors could be supported or partially given conformation in the light of the empirical findings, which is an indication on the theories based on these factors and their application to both pharmaceutical industry and China. Thus these findings also apply to both the pharmaceutical industry as well as China. Similarly by refuting some factors on the grounds of expiration brought on by changes in the world the author can provide suggestions on further research not to delve on these issues.

As the theoretical basis for factors was sound the author was also able to support some of the factor frameworks presented in the literature and thus contribute to the theoretical understanding. By corroborating the importance of Boddewyn's (1985) framework, which clearly lays out the basic conditions for R&D, the author contributes the basic requirements on R&D globalization for a country or location to theoretical understanding. Furthermore Boddewyn's (1985) framework presents the decision process and the most important motivations for globalization of R&D. By supporting these findings the author increases theoretical understanding by presenting the framework as a thought experiment on whether a company should consider R&D globalization and as the first part on the decision process presented in this paper on how to choose an appropriate governance form. By pointing out the lack of market considerations as motivations instead of precipitating circumstances in Boddewyn's (1985) framework the study also contributes to the theoretical understanding of company's motivations.

These frameworks also included Kuemmerle's (1998) division on whether to continue catering to its home market, utilizing resources available in the offshore location by thus furthering its competitive position and introducing new products, or whether it wants to access the host market by capitalizing on the existing capabilities at home. The study makes a theoretical contribution by drawing similarities between choosing a home-base-exploiting (HBE) and home-base-augmenting (HBA) strategy and choosing between R&D internationalization and R&D offshoring as governance forms. Similar contribution is the exclusion of R&D offshore outsourcing from Kuemmerle's (1998) framework, based on his hypothesis of company's own capabilities.

A framework by Granstrand et al. (1993) presents an evolutionary view of operations supported by Ronstadt (1977) that illustrates how the operations and their part in the value chain evolve once the company has attained a certain position in the local market, leading to setting up local adaptive R&D when the inducements become pressing, highlighting the case for market dependent R&D internationalization. They also provide a strong case for environmental factors and evaluation of both micro and macro factors (Granstrand et al. 1992).

The author contributes to theoretical understanding by including this process and environmental factors in the decision framework presented (1. as part of the initial framework/ 2. in chapter 2.2 as derived from previous frameworks presented in literature). The author presents the findings of Granstrand, et al. (1993; 1992) as a step to evaluate whether environmental factors support market exploitation with multiple locally situated business functions by transforming existing operations or with multiple completely novel operations that favor demand driven home-country exploiting through R&D internationalization versus lesser involvement through supply driven offshoring.

A framework by Beckmann and Fischer (1994) illustrate how company's underlying input-driven or output-driven motivations can be superseded in importance by external, efficiency and socio-cultural drivers. Furthermore they show how with lack of market, labor or technology motivations the only motivations can be external, efficiency and socio-cultural drivers together with cost considerations, financial incentives, legal requirements or political considerations such as trade barriers. By protracting these findings the author contributes to the theoretical understanding on the legitimacy for R&D offshore outsourcing as a governance form in relation to R&D offshoring and internationalization of R&D including their findings to author's decision framework.

The above mentioned influencing factors and frameworks are all derived from previous literature and empirically scrutinized in this study. From the interviews the author was also able to discern further influences to R&D globalization not handled in the literature. Von Zedtwitz and Gassmann (2002) have notified the inherent difference of research in comparison to development and its effect on the R&D globalization process. As development varies from research, the different development tasks can vary from one another and different research tasks such as basic research may differ from i.e. from applied research to the same degree (Iansiti 1993; Lall 1979).

Building upon this research the author contributes to theoretical understanding by illustrating that the actual R&D function to be globalized should also be taken into consideration on the level of different parts of the drug discovery process, which influences what factor derived benefits can be exploited. This is especially true for R&D in industries such as pharmaceutical industry, whose R&D process covers many fields of science, moves up the value chain and has very different requirements for its distinct parts (Cooke 2005). Hence all stages of the earlier drug discovery as well as all the phases of

clinical trials need to be considered separately when making decision on R&D globalization.

The initial framework presented by the author takes into account the pharmaceutical drug discovery process and scrutinizes governance forms together with the drug discovery process on a continuum, which as whole is influenced by factors. This type of continuum has not been covered in the academic literature beyond the distinction to research compared to development or basic in relation to applied. The drug discovery process was grouped to four major parts: pre-discovery, discovery, preclinical and clinical. There exist very differing requirements for all these parts, which are thusly influenced by distinct factors and separate governance forms on a continuum based on the influencing factors.

Here we acknowledge that this is a crude division as all these parts contain both development and research tasks, are divided to multiple subparts that all include a variety of different scientific disciplines and experiments. Nevertheless, the influencing factors most strongly associated with pre-discovery are the effect of national innovation systems, centers of excellence and financial incentives. The influencing factors that play the greatest part in discovery are: cross-country cost differentials and availability of labor, although basic infrastructure requirements are seen as a conditional factor. The influencing factors chiefly involved in preclinical stage are: local science and technology, new technology output, local requirements and quality control risks. Market access, local and market requirements, customer information as well as the local advantage of sizeable patient pool and operating efficiency are factors influencing clinical phase drug discovery with greatest risk stemming from inadequate healthcare, hospital or other infrastructure.

5.2 Managerial Implications

Chronological examination would suggest that R&D globalization has first been cost driven manufacturing development that has expanded to higher value added R&D activities while chiefly servicing the Chinese market instead of improving manufacturing of products sold at home market. The focus on the Chinese market was evident in the interviews and came out as a decisive factor.

China is on trajectory to become the second biggest market for pharmaceuticals. The industry is experiencing annual double digit growth rate, the highest in the world and above average percentage for spending on medicines of total healthcare spending. All these economic realities make it the most attractive pharmaceutical market in the world. As market access was found to be the major determining factor in this study, the managerial implications of this finding according to the author is that for Big Pharma to sustain profitability, involvement in the Chinese pharmaceutical market is a must and most

efficiently achieved by placing R&D and other higher value added operations to China via the process of R&D internationalization. From the clinical trial point of view China has the world's greatest patient population, which is relatively untouched by wide usage of chronic medication. In drug discovery sense the managerial implication is that conduct of local R&D, chiefly the replication of clinical trials for pharmaceutical registration is basically a requirement for market access in China for pharmaceutical industry. The managerial implication of the Chinese market to the R&D of small and medium sized companies is that although it is not a decisive factor, its importance is evident when acquiring finance or attempting to license products or attracting larger pharmaceutical companies as a M&A target. The market potential, availability of patients for clinical trials together with the government's strict enforcement of the Chinese pharmacopoeia standard as a condition for any market approval suggests that clinical trials of drugs that target the Chinese market or global trials would be beneficial to be conducted in the PRC, and best achieved through R&D internationalization.

One of the main reasons for conducting technical research abroad is the difficulties in receiving permits from local institutions. In the pharmaceutical industry, importance of government regulations and requirements are highly pronounced and application times can total several years. This is the case in China as well, if not even more pronounced for two reasons. Firstly, in exchange for a marketing permission, the government requires research to be conducted in the country and according to local standards and requirements. Thus the acquisition of permits is tightly linked to capitalizing on the Chinese market potential and is a direct way the government guides market interest. The second reason is that the Chinese government and the relevant institutions are extremely cautious in approving medicines that have not been approved outside of China, with more rigorous demands on safety and efficacy leading ultimately to longer application times that can even hinder international trials. For these historical reason two different regulatory drug approval channels exist, one to already tested according to FDA or EMA specifications and another for drugs with preliminary first clinical trials in China.

The most notable permits under the Drug Administration Law of the People's Republic of China are production permission and/or marketing approval following a successful drug registration application to Provincial Drug Administration Authorization (PDAA), which is similar to NDA application in the US. The application is ultimately approved by The State Food and Drug Administration (SFDA). An earlier permit, especially of importance to smaller pharmaceutical companies is clinical trial application filled to Therapeutic Goods Administration of SFDA.

There exist clear cross-country cost differentials between China and the western countries, which can be taken advantage of through pharmaceutical R&D globalization. This is especially in R&D functions where majority of costs are comprised of personnel cost differences.

In certain parts of China there is a lack of basic infrastructure from clean water to reliable electricity supply but also a deficiency of governmental and institutional data and support such as hospital and patient information, sales and market figures and lack of certain technologies. Similar infrastructure constraints are deficiencies in supply chain, pharmacies and hospital practices.

Government incentives, especially infrastructure or cash incentives, in the case of smaller pharmaceutical companies should be taken into consideration when making decisions on R&D globalization based on fiscal factors. In the case of Big Pharma or blockbuster drugs in general, when selecting a host market-driven model tax incentives can be second in importance to the market potential and size.

Although potential savings on labor cost would be substantial, infrastructure costs can surmount to sizeable sums and the case is complicated by government incentives that can be a make or break form of soft money for early stage companies, while in certain cases tax subsidies can hugely increase profitability regardless of all other factors. When determining the actual fiscal situation around firms R&D globalization, all these cost considerations and incentives should be carefully evaluated and taken into account in order to reach an informed decision. In the drug discovery sense according to the author and based on the empirical research presented in this paper the managerial implication of this is that cost emphasis plays a part in the earlier phases where personnel costs make up the bulk, a case which is almost synonymous with offshoring manufacturing to China. According to the author in pre-discovery stage the risk posed by infrastructure failings are also minuscule and should be considered when evaluating centers of excellence.

An historical shift in thinking that changes the paradigm of China as the factory of the world to the second biggest market coincides with a general improvement in both basic and advanced infrastructure in the country together with the unification of international patenting standards and stronger enforcement of IP rights in China, which have created the basic conditions required for R&D globalization as presented by Boddewyn (1985). Contrary to layman's view of IP protection in China, the state of patent and formal codified IP protection has improved substantially since China's ascension to WTO on 11 December 2001.

Nevertheless issues dealing with intellectual property rights present a challenging case in China. Most vocally this has to do with protecting uncodified IP, such as safeguarding core technologies, production processes, trade secrets and proprietary technology. This is extremely important but at the same time very challenging in China. Safety measures and standards are sometimes used both in the developed countries and even more so in developing countries like China to facilitate technology transfer and increase FDI to the target country. Furthermore in China especially applying for production permission, marketing approval and clinical trial approval requires wide open disclosure and cooperation with stakeholders, which makes it extremely difficult to safeguard un-

codified IP. Although surprising, a common practice to protect such uncoded IP on global markets has been to establish operations to China with strong legal emphasis.

Another IP concern in China is the potential for unintended technology transfer or theft that can result in a leak of core competencies to a local competitor or fostering a new competitor inside the company. This issue of technology walking out of the front door is present in any country but due to cultural, institutional and legal differences with West a more of a pressing issue. Generally speaking there is an insufficient understanding of the Chinese legal environment and business practices, such as suitable composition of senior management and distribution of decision making power.

Although some issues on IP have improved, China's legal protection on uncoded IP still presents a challenge to both small and large companies, with Yahoo and Alibaba as an example. With China's convergence to international patenting laws, the codified IP can be reasonably well protected and investment in it as well as on rigorous security practices to protect uncoded IP together with management rotation and retention of decision making overseas can be considered as necessary infrastructure for doing business in China. In the early phases of drug discovery the IP risks are most negligible and the IP structure of PRC is less of a concern and thus prediscovery and discovery are beneficial stages for R&D globalization if simultaneously capitalizing on other factors.

The value of networks and personal connections in China can not be overstated, thus it is extremely important that both larger and smaller pharmaceutical companies are in cooperation with public institutions, such as research centers, science parks and universities that provide a trustworthy, influential and ready platform for building networks on institutional, governmental and industry level.

For larger pharmaceutical companies this is most efficiently achieved by supporting university faculties, renowned professors and promising graduates, which also provides them with steady stream of advanced labor. On top of the networks in these centers of excellence, small and middle sized pharmaceutical companies can utilize the facilities and infrastructure such as laboratories and offices readily available instead of building their own. These type of centers of excellence are dependent on public funding, when making location decision it should be verified that the content and emphasis of national or local innovation systems applicable are aligned to company's needs.

Centers of excellence can also exist in industry clusters or as individual companies operating in science parks and special economic zones, expertise that can be most efficiently accessed through supplier relationships or CRO, CMO service provider agreements. In the pharmaceutical industry the area spanning from Shanghai through Tianjin all the way to begin host the highest excellence, with Shanghai as the centre of Chinese pharmaceutical, biotechnology and healthcare sector. In drug discovery sense prediscovery stage R&D can be seen as dependent on centers of excellence and a global network of R&D cooperation with renowned specialist, which are dependent on public funding and thus the content and emphasis of national or local innovation systems

should be taken into account when making location decision on prediscovery stage pharmaceutical R&D.

The insurmountable amount of cheap advanced labor resources in PRC can be a source of cost advantage, but chiefly it is a way to supplement scarce resources at home, achieve minimum critical mass and economies of scale through R&D globalization. It is further augmented by the expertise of returning Chinese, who are an extremely important labor resource in China. Ultimately it is a way to do more with the same resources and in the drug discovery sense it is most visible in chemical or component production, API formulation and discovery stage R&D, in which the huge R&D labor pool of graduate scientist and engineers in China strongly support R&D globalization to PRC.

The sizeable advanced labor resources in PRC speak on behalf of conducting labor intensive fairly standardized early drug discovery R&D(Paul et al. 2010), such as hit-to-lead, lead prioritization, lead optimization in PRC through offshoring or through offshore outsourcing in the case of smaller companies, which may lack said competencies.

The decision framework the author presented in chapter 2.2 as derived from previous frameworks presented in literature provides managers with a clear roadmap to make decisions on R&D globalization. The author contributes to managerial decision making by combining these frameworks to a governance form flowchart presented in picture 4.

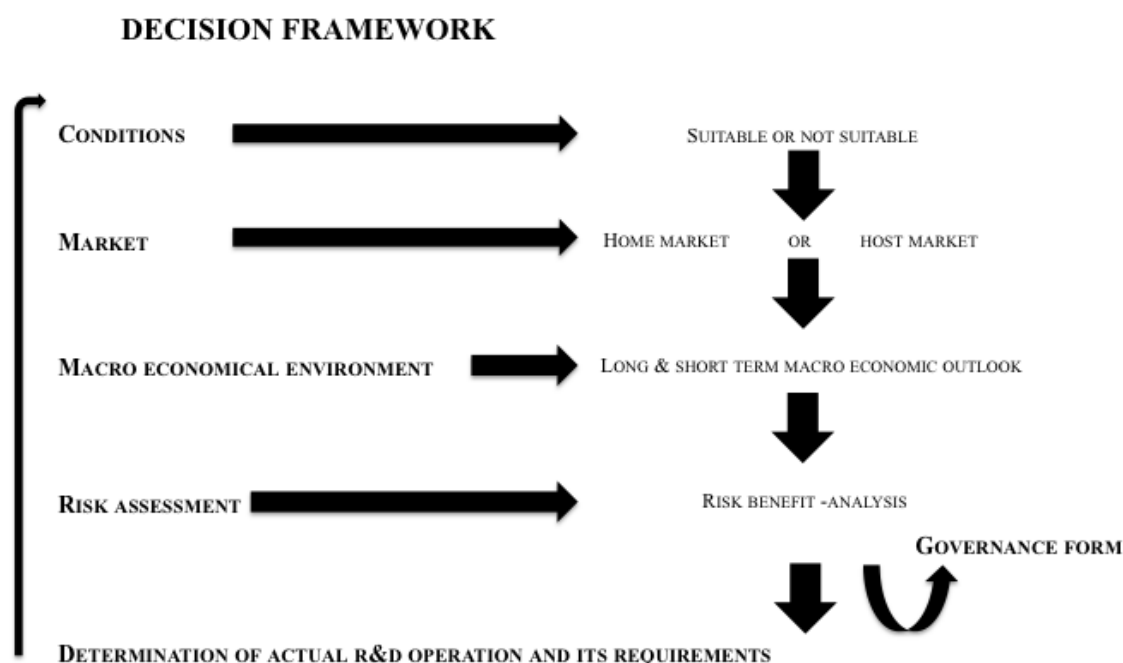


Figure 4. Flowchart on governance form decision framework

The first step is to determine if the necessary basic infrastructure is available in the target country to reach a "go" or "no go" -decision. If a "go"-decision is awarded, the second step is to determine the target market in question, reflecting the importance of

market as an influencing factor and thus choose between demand driven R&D internationalization or supply driven R&D offshoring.

The third step is to evaluate the effects of macroeconomic factors to decide on the overall attractiveness of the country and thus choose the magnitude of involvement, time span of strategy and resources committed. If the macroeconomic conditions are not supporting the decision for R&D internationalization, then the market potential must be weighted against these factors to re-evaluate the magnitude of involvement and whether conditions are more suitable for other governance forms.

The fourth step is to determine if the environmental infrastructure and risk factors, mainly external, efficiency and socio-cultural drivers support in-house operations in the target country or whether all benefits derived from influencing factors can be achieved by offshore outsourcing. This step also involves a company's culture on risk taking and risk management, whether it is more acceptable to be exposed to uncertainty and risk than wager on losing a potential benefit or business opportunity, or whether it is more acceptable to loose on a business opportunity than be exposed to risks and uncertainty.

The last and fifth step is to decide whether it is development, research or both that is intended to be globalized, with determining the actual operation in question at least to the resolution of drug discovery part and its individual requirements. The pros and cons of chosen operation and its necessary requirements are then subjected to review through steps one to four ultimately leading to the validation of chosen governance form.

6 SYNOPSIS

Firm's survival and success, which are dependent on its ability to innovate, to create knowledge and to capitalize on inventions and know-how, is in essence directly linked to its R&D process. Especially in technology driven industries, such as the pharmaceuticals, there are significant positive returns to R&D investments through introduction of new or improved products and services. Technological lead and its transformation to innovative products as fruits of corporate R&D can be seen as monopolistic advantage that helps enterprises to compete in today's market. This competitive advantage can be derived from corporation's ability to integrate its activities across geographic locations.

Globalization of R&D is intervened with the changes in global economy of the 21st century. Some studies argue for the driving forces to be access to vast skilled labor pools and centers of excellence. Other studies indicate the R&D cost differentials between countries to be the major expected benefit. Related factors like financial incentives have also been said to play a part.

Access to markets has been seen as an important factor along with other market-driven factors, such as product adaptation and legal requirements. Similarly some studies have found risk and conditional factors that influence R&D globalization. As many of the studies have been inconsistent and none of the influencing factors alone have been sufficient to illustrate this phenomenon, researchers have grouped influencing factors into frameworks based on multiple factors that has been able to more fully explain parts of the phenomenon and portray it as one covering multiple variations of the same phenomenon.

This study proposes that especially in industries such as the pharmaceutical industry distinct benefits can be capitalized based on the R&D globalization governance form the company utilizes. These governance forms for R&D globalization are: offshoring of R&D, offshore outsourcing of R&D and internationalization of R&D. Studies have notified the inherent difference of research in comparison to development and its effect on the R&D globalization process. Further studies have shown how development varies from research, the different development tasks can vary from one another and different research tasks such as basic research may differ from i.e. from applied research to the same degree. Building upon this research the author illustrates that the actual R&D function to be globalized should also be taken into consideration on the level of different parts of the drug discovery process, which influences what factor derived benefits can be exploited. The purpose of this research is to identify factors influencing the globalization of pharmaceutical R&D in PRC and how these factors affect the different governance forms on a continuum of pharmaceutical drug discovery. This research attempts to fulfill the above mentioned purpose by answering to the following research question:

"How to determine the appropriate governance forms for globalization of pharmaceutical R&D for international pharmaceutical companies in the context of PRC based on the influencing factors?"

The research question is divided into the following subquestions with the objective that when the subquestions are answered they will provide a complete and coherent answer to the main research question:

"What are the different factors influencing the internationalization of pharmaceutical R&D to PRC?"

"What are the different factors influencing the offshore outsourcing of pharmaceutical R&D to PRC?"

"What are the different factors influencing the offshoring of pharmaceutical R&D to PRC?"

"How does the continuum formed of pharmaceutical drug discovery's stages influence the globalization of pharmaceutical R&D in the context of PRC?"

The research question divides the R&D globalization phenomenon to the different governance forms as its subconcepts. Together the different governance forms cover the whole R&D globalization phenomenon from different operational points of view. While offshoring illustrates the operation of transferring activities across national borders using internal resources, it is an immediate, short time span strategy designed to augment company's existing resources in its home market competition. In contrast, internationalization has been viewed as a process of increasing involvement in international markets, through building on existing activities and the growing tendency of operations to span across national boundaries. Furthermore the practice of company entrusting to an external entity based in other countries the performance of an activity is commonly referred to as offshore outsourcing.

The three above listed concepts are innately separate, follow different motivations and are associated with different factors influencing globalization of R&D. Thus factors can be categorized based on the benefits capitalized with the governance forms. Even though factors influencing industrial R&D on an international scale are numerous and varied, their wider implication can be conveniently distinguished from classifications into groups that better illustrate their implication. Different approaches have been used to classify factors influencing R&D globalization.

One such classification approach based on Aristotle's ideas of condition-motivation-precipitating circumstances framework lays out the basic conditions for R&D in any given country in a world as well as describes the decision process from the basic condi-

tions to the underlying motivations all the way to the precipitating circumstances that ignite the spark for R&D globalization.

Another framework divided reasons for globalization of R&D into two categories of R&D globalization: home-base-exploiting (HBE) and home-base-augmenting (HBA). The framework presents firms as entities seeking to exploit specific capabilities present in their organization in a foreign environment or building new firm-specific advantages from resources present in the foreign environment. Thus it is drawing a distinction between R&D offshoring and R&D internationalization.

Another classification approach differentiates between demand-oriented and supply-oriented drivers for R&D internationalization. While clarifying the distinction between R&D offshoring and R&D internationalization based supply/demand concepts it also illustrates the micro, macroeconomic duality of factors and how that may have an impact on a company level.

A more refined classification scheme presents five categories of R&D globalization drivers: input-oriented, output-oriented, external, efficiency-oriented and political/social-cultural. The framework stresses the importance of external, efficiency and socio-cultural drivers as complementary to either the input-driven or output-driven factors. Furthermore, the framework presents the influence of external, efficiency and socio-cultural drivers, when neither market nor advanced R&D resources are fundamental. Thus the framework illustrates the legitimacy of R&D offshore outsourcing as a governance form in relation to R&D offshoring and R&D internationalization.

Based on corresponding classification, a separate framework divided factors affecting globalization of R&D into five corresponding categories: quality of the input at the foreign site, quality of expected output, external drivers on R&D globalization and factors dealing with the general operating efficiency as well as political and socio-cultural issues.

A novel framework dwelling onto R&D reveals the inherent difference of research in relation to development. Similarly this work together with complementary studies shows the continuum of basic to applied research and difference of diverse development tasks. Furthermore an additional framework show how research and development are subjective to different location drivers, which they list as access to local markets and customers as well as access to local science and technology. This framework also illustrates the relation of factors to company's and operation's size.

A classification within the Chinese context merges the aforementioned output and efficiency-oriented motivation factors into performance-oriented motivation factors while combining the external and political/social-cultural into business-ecological motivation factors. Thus the framework presents the implications of different factors and their relations in the conditions of PRC.

However despite the numerous advantages that can be capitalized with R&D globalization, managerial practices to evaluate opportunities are scarce, knowledge among

practitioners lacking while the research remains fragmented and inconclusive. Existing literature identifies numerous influencing factors and illustrates their relationships and connection to company features but fails to provide guidelines on how to capitalize on them.

A qualitative research approach has been followed in this research. Multiple in depth expert interviews were conducted on par with secondary data collection to understand the phenomenon and its implications. Furthermore, the research utilized a combination of deductive and inductive reasoning, which is based on testing the existing theories, corroboration of the previous findings to a large extent and then constructing a revised initial framework to accommodate the unique empirical findings. An initial framework was developed based on the existing literature and findings. Operationalization of the main research question was constructed on that preliminary framework. Also, when conducting interviews the themes of the research were kept in mind. This helped in the conduct of the interviews and provided a sound methodology. Hence it can be said that along with working as the base for the operationalization of the research question, the initial framework has been tested against the business reality of pharmaceutical managers, directors and experts.

To corroborate or refute factors and their relations on the governance forms of globalized R&D an empirical study was conducted from the perspective of pharmaceutical industry managers in the case of People's Republic of China. In order to answer the above mentioned research question an empirical qualitative research was conducted in China. The research is based on 8 qualitative expert theme interviews with local pharmaceutical directors and managers conducted in 2011-2012, utilizing theme interview method with few standardized guiding open ended questions and validating findings using a semi-structured research questionnaire.

In the concluding part of the thesis, the theoretical implications of corroborating some factors, refuting others and conditionally corroborating some are pondered. Similarly as the factor basis for frameworks is found sound, the frameworks are scrutinized through their apparent connection to the R&D globalization governance forms. Furthermore, information derived from the frameworks can be used to select the most suitable governance form based on their correlation.

Additionally, managerial implications of the study are discussed which can be used to facilitate understanding on capitalizing different factor derived benefits in the Chinese context. Furthermore a decision framework has been developed, which accommodates the pharmaceutical R&D dependant findings of the study along with including the existing knowledge on factor frameworks, which have been confirmed through the empirical investigations. The decision framework provides a tool for managers to evaluate their operations and the fiscal value of benefits that can be derived from R&D globalization.

7 REFERENCES

- Abetti, P. A. (1985). Milestones for managing technological innovation. *Strategy & Leadership*, 13(2), 18-46.
- Adler, N., & Hashai, N. (2007). Knowledge flows and the modelling of the multinational enterprise. *Journal of International Business Studies*, 38(4), 639–657.
- Allen, T. J., Lee, D., & Tushman, M. L. (1980). R&D performance as a function of internal communication, project management, and the nature of the work. *Engineering Management, IEEE Transactions on*, (1), 2-12.
- Ambrecht, F.M.R. (2002) WTO entry, government's welcome could spur foreign R&D in China. *Research and Technology Management*, 45, 5, 2–5
- Athukorala, P. C., & Kohpaiboon, A. (2010). Globalization of R&D by US-based multinational enterprises. *Research Policy*, 39(10), 1335-1347.
- Brockhoff, K. (2003). Exploring Strategic R&D Success Factors. *Technology Analysis & Strategic Management*, 15(3):333-348
- Bardhan, A. D. (2006). Managing globalization of R&D: Organizing for offshoring innovation. *Human Systems Management*, 25(2), 103-114.
- Bardhan, A.D. and Kroll, C. The New Wave of Outsourcing. Fisher Center for Real Estate & Urban Economics Research Report, October, 2003.
- A.D. Bardhan and D.M. Jaffee, R&D, Innovation and Outsourcing, Fisher Center for Real Estate & Urban Economics Research Report, October, 2005.
- Barr, A., & Tessler, S. (1996). The Globalization of Software R&D: The Search for Talent. Council on Foreign Relations' Study Group on the Globalization of Industrial R&D.
- Bartlett, C.H., Ghoshal, S. (1989). *Managing Across Borders: The Multinational Solution*. London. Second edition (1998) Harvard business school press, Boston, Massachusetts, USA, 65–82, 85–108
- Bartlett, C. A., & Ghoshal, S. (1990). Managing innovation in the transnational corporation. *Routledge, London*, 215–255. *Managing the Global Firm* edited by Christopher A. Bartlett, Yves Doz, Gunnar Hedlund
- Beckmann, C. & Fischer, J. (1994). Einflußfaktoren auf die Internationalisierung von Forschung und Entwicklung in der Chemischen und Pharmazeutischen Industrie. *Zeitschrift für Betriebswirtschaftliche Forschung*, 46, 7/8, 630–657. Translated from German by Laura Sauvageot and Tuula Sauvageot
- Behrman, J. N and Fischer, W. (1979). The coordination of foreign R&D activities by transnational corporations. *Journal of International Business Studies*, 10(3), 28-34
- Behrman, J. N. and Fischer, W. A. (1980). Overseas R&D activities of transnational companies. *The International Executive*, 22(3), 15-17.

- Benner, M., & Sandström, U. (2000). Institutionalizing the triple helix: research funding and norms in the academic system. *Research Policy*, 29(2), 291-301.
- Bleicher, K. H., Böhm, H. J., Müller, K., & Alanine, A. I. (2003). Hit and lead generation: beyond high-throughput screening. *Nature Reviews Drug Discovery*, 2(5), 369-378.
- Boddewyn, J. J. (1985) Theories of foreign direct investment and divestment: A classificatory note. *Management International Review*, 25: 57-65.
- Boehe, D., M. (2008) In-house off-shoring of product development by MNCs
(Boutellier et al. 1999) (Boutellier, Gassmann, & Zedtwitz, 1999)
- Boutellier R., von Zedtwitz, M., Gassmann O. (2004). Organizing global R&D: challenges and dilemmas. *Journal of International Management* 10: 21–49
- Buckley, P., & Casson, M. (1976). *The future of the multinational enterprise*. London: The McMillan Press Ltd. p. 53-54)
- Buckley and Casson 1985 (Buckley and Casson 1985)
- Buckley, P. J. and Casson. M. C. , editors. (1985) *The economic theory of the multinational enterprise*. New York, US Macmillan.
- Buckley, P. J., & Casson, M. C. (1998). Models of the multinational enterprise. *Journal of International Business Studies*, 21-44
- Buckley, P. J. & Casson, M. C. (2009). The internalisation theory of the multinational enterprise: A review of the progress of a research agenda after 30 years *Journal of International Business Studies* 40, 1563–1580 *Brazilian Administration Review* 5(1): 1-18.
- Burney, S. M. Aqil (2008) Inductive and deductive research approach. University of Karachi.
<http://www.drburney.net/INDUCTIVE%20&%20DEDUCTIVE%20RESEARCH%20APPROACH%2006032008.pdf>, retrieved 05.10.2012
- Cantwell, J. (1994). Transnational corporations and innovatory activities. *The United Nations' Library on Transnational Corporations*, Vol. VIII. London, .8, 15–23
- Carlsson, B. (2006). Internationalization of innovation systems: A survey of the literature. *Research policy*, 35(1), 56–67.
- Casson, M., & Singh, S. (1993). Corporate research and development strategies: the influence of firm, industry and country factors on the decentralization of R&D. *R&D Management*, 23(2), 91–108.
- Cayen, Mitchell N. (2010). *Early Drug Development: Strategies and Routes to First-in-Human Trials*. Hoboken, NJ, USA: Wiley, 3–450.
- CFDA, (30.3.2012 14.06) *Good Manufacturing Practice for Drugs (2010 Revision)*
<http://eng.sfda.gov.cn/WS03/CL0768/65113.html>

- Cheng, J. L. & Bolon, D. S. (1993). The management of multinational R&D: a neglected topic in international business research. *Journal of International Business Studies*, 1-18.
- Chen, L. H., & Hung, C. C. (2010). An integrated fuzzy approach for the selection of outsourcing manufacturing partners in pharmaceutical R&D. *International Journal of Production Research*, 48(24), 7483-7506.
- China Pharmacopoeia Committee. (2005). Third book: Biologicals Chinese Pharmacopoeia: Hua Xue Gong Ye Press, Beijing, China
- Clark, K. B., and Fujimoto, T. (1991). *Product development performance: strategy, organization and management in the world auto industry*. Boston: Harvard Business School Press.
- Clark, K. B., and Wheelwright, S. C. (Eds.). (1994) *The product development challenge: Competing through speed, quality, and creativity*. Harvard Business Press. Boston, MA, USA, p. 43-60
- Cleland, D. I., and King, W. R. (1983). *Systems analysis and project management (Vol.3)* McGraw-Hill. New York, USA
- Cleland, D. I., Kocaoglu, D. F., Brown, J., & Maisel, J. W. (1981). *Engineering management*. New York: McGraw-Hill.
- CNN, Fortune 500. (2009 July 20). *The List Industries Pharmaceuticals Fortune Global 500 Vol. 160 (2)*
- Cockburn, I., M. (2008). Chapter 6 Pharmaceuticals. Boston University and National Bureau of Economic Research. 207–2014 in Macher, J. T., Mowery, D. C. (eds). (2008). *Innovation in Global Industries: U.S. Firms Competing in a New World (Collected Studies)*. Board on Science, Technology, and Economic Policy (STEP), Washington D.C.: The National Academies Press. http://books.nap.edu/openbook.php?record_id=12112&page=R1
- Contractor, F. J., and Sagafi-Nejad, T. (1981). International technology transfer: Major issues and policy responses. *Journal of International Business Studies*, 113-135.
- Cooke, P. (2005). Rational drug design, the knowledge value chain and bioscience megacentres, *Camb. J. Econ.* 29 (3): 325–341.
- Cooper, R. G. (1983). The new product process: an empirically- based classification scheme. *R&D Management*, 13(1), 1-13.
- Creamer, D. (1976). *Overseas Research and Development by United States Multinationals 1966-1975*, N. York: The Conference Board, 35, 5, 72
- Crossley, R. (2004). The quiet revolution: outsourcing in pharma. *Drug discovery today*, 9(16), 694.
- Davis, L. (2000). Multinational research subsidiaries in Denmark. The emergence and impact of MNC centers of excellence—a subsidiary perspective, 113-130.

- De Meyer, A. & Mizushima, A., (1989). Global R&D management. *R&D Management*, 19(2):135-146.
- De Boer, S. J., Gan, W., & Shan, G. (1998). Critical issues facing R&D managers in China. *R&D Management*, 28(3), 187-197.
- Depret, M., Hamdouch, A. (2000) Innovation Networks and Competitive Coalitions in the Pharmaceutical Industry: Emergence and Structures of a New Industrial Organization, *European Journal of Economic and Social Systems*, n° 3, p. 229-270. Freely available on: www.edpsciences.org/articles/ejess/pdf/2000/03/depret.pdf
- DeRuiter, J., Holston, P. L. (2012). Drug Patent Expirations and the “Patent Cliff” U.S. Pharm. 2012; 37 (6), (Generic suppl):12-20
- Di Minin, A., & Bianchi, M. (2011). Safe nests in global nets: Internationalization and appropriability of R&D in wireless telecom. *Journal of International Business Studies*, 42 (7), 910–934
- Dunk, A. S., Kilgore, A. (2001). Short-term R&D bias, competition on cost rather than innovation, and time to market *Scandinavian journal of management* 17, 409–420
- Dunning, J. H. (1994). Multinational enterprises and the globalization of innovatory capacity. *Research policy*, 23(1), 67-88.
- Dunning, J. H. (1999) Trade, location of economic activity and the multinational enterprise: a search for an eclectic approach. PJ Buckley & P. Ghauri. *The internationalization of the firm*, 61–79.
- Dunning, J. H., & Lundan, S. M. (2009). The Internationalization of Corporate R&D: A Review of the Evidence and Some Policy Implications for Home Countries1. *Review of Policy Research*, 26(1-2), 13–33.
- Dunning, J. H., & Narula, R. (1995). The R&D activities of foreign firms in the United States. *International Studies of Management & Organization*, 25(1/2), 39-74.
- Dunning, J. (1958). *American Investment in British Manufacturing Industry*. London, George Allen and Unwin.
- Eldred, E., McGrath, M., 1997a. Commercializing new technology - I. *Research Technology Management* 40 (1), 41–47.
- Eldred, E., McGrath, M., 1997b. Commercializing new technology - II. *Research Technology Management* 40 (2), 29–33
- Eskola, J., and Suoranta, J. (1998). Johdatus laadulliseen tutkimukseen Osuuskunta vastapaino, Gummerus Oy, Jyväskylä, 65–77
- Feinberg, S. E., & Gupta, A. K. (2004). Knowledge spillovers and the assignment of R&D responsibilities to foreign subsidiaries. *Strategic Management Journal*, 25 (8- 9), 823-845.

- Fossey, Ellie – Harvey, Carol – McDermott, Fiona – Davidson, Larry (2002) Understanding and evaluating qualitative research. *Australian and New Zealand Journal of Psychiatry*, Vol. 36, 717 – 732.
- Freeman, C. (2003). A Schumpeterian renaissance. SPRU, SEWPS.
- Franko, Lawrence G. (1989). Global corporate competition: Who's winning, who's losing, and the R&D factor as one reason why. *Strategic Management Journal*, 10: 449-74
- Fischer, W., & Behrman, J. N. (1979). The coordination of foreign R&D activities by transnational corporations. *Journal of International Business Studies*, 10(3), 28-34
- Florida, R., & Kenney, M. (1994). The globalization of Japanese R&D: the economic geography of Japanese R&D investment in the United States. *Economic Geography*, 344-369.
- Florida, R. (1997). The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. *Research policy*, 26(1), 85-103.
- Foray, D. (2006). Globalization of R&D: linking better the European economy to foreign sources of knowledge and making EU a more attractive place for R&D investment. *Knowledge for Growth*”, European Commission.
- Ford, D., Gadde, L., Håkansson, H., Lundgreen, A. Snehota, I. Turnbull, Peter. W., David (2003) *Managing Business Relationships*. John Wiley & Sons Ltd, Chichester.
- Gad, S. C. (Ed.). (2005). *Drug discovery handbook* (Vol. 1). Wiley, Hoboken, NJ, USA, p. 1–561
- Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&D Management*, 40(3), 213-221.
- Gassmann, O., Han, Z. (2004). Motivations and barriers of foreign R&D activities in China. *R&D Management*, 34(4), 423-437
- Gassmann, O., von Zedtwitz, M. (1998). Organization of industrial R&D on a global scale. *R&D Management*, 28(3), 147-161.
- Gassmann, O., von Zedtwitz, M. (1999). New concepts and trends in international R&D organization. *Research Policy* 28(2–3) 231–250
- Gerlach, M., (1993) *Alliance Capitalism: The Social Organization of Japanese Business*. Berkeley, CA Nonaka, I., Takeuchi, H., 1995.
- Gerybadze, A., (1995) *Strategic Alliances and Process Redesign: Effective Management and Restructuring of Cooperative Projects and Networks*. Berlin.
- Gerybadze, A., Reger, G. (1999) Globalization of R & D: recent changes in the management of innovation in transnational corporations. *Research Policy* 28 251 – 274

- Glismann, H. H., and Horn, E. J. (1988). Comparative invention performance of major industrial countries: patterns and explanations. *Management Science*, 34(10), 1169-1187.
- Ghoshal, S., & Bartlett, C. A. (1988). Creation, adoption, and diffusion of innovations by subsidiaries of multinational corporations. *Journal of International Business Studies*, 365-388.
- Golnam, A., Ebrahim, A. N. and Ghazizadeh, A. (2007). Globalization of R&D and Developing Countries. <http://ideas.repec.org/a/cpn/umkeip/2012v4p61-74.html>. Article provided by Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika in its journal *Ekonomia i Prawo*. Volume (2012): 4. 61–74
- Grossman, G. M. Hansberg, E. (2006). The rise of offshoring: it's not wine for cloth anymore. *The New Economic Geography: Effects and Policy Implications*, p. 59-102.
- Grossman, G. M., Hansberg, E. R. (2008), Trading Tasks: A Simple Theory of Offshoring, *American Economic Review*, vol. 98, n°5, p. 1978-1997.
- Grossman, G. M., Helpman, E. (2003). Outsourcing versus FDI in industry equilibrium. *Journal of the European Economic Association*, 1(2- 3), 317-327.
- Granstrand, O., Håkanson, L. and Sjölander, S. (1993) Internationalization of R&D – a survey of some recent research. *Research Policy*, 22, 413–430.
- Granstrand, O., Håkanson, L. & Sjölander, S. (eds) (1992) *Technology Management and International Business: Internationalization of R&D and Technology*. Chichester: Wiley.
- Grönfors, M. (1982). *Kvalitatiiviset tutkimusmenetelmät*. Juva: WSOY.
- Hamdouch, A. & He, F. (2009) R&D offshoring and clustering dynamics in pharmaceuticals and biotechnology: key features and insights from the Chinese case
- Harisalo, Risto ym. (2002), *Otin kynän kynsijälle*. Tampereen Yliopistopaino Oy, Tampere
- Hart, S. J.(1991) A first time user's guide to the collection and analysis of interview data from senior managers. p. 190 - 203 In the book: Smith, C., N., Dainty, P. (Eds.): *The management research handbook*, New York: Routledge.
- Harvey, A. (2001). The continuing value of natural products to drug discovery. *GIT Laboratory journal*, 5(6), 284-285.
- Hewitt, G. (1980) Research and development performed abroad by U.S. manufacturing multinationals. *Kyklos*, 33: 308-27.
- Hewitt, G.1983. Research and development performed in Canada by American manufacturing multinationals. In Alan M. Rugman, editor, *Multinationals and technology transfer--The Canadian experience*, 36-49. New York, NY: Praeger.

- Hedlund, G. (1993). *Organization of transnational corporations* United Nations library on transnational corporations Routledge Vol. 6 London, 4-5, 8-10
- Hendry, J. (1995). Culture, community and networks: The hidden cost of outsourcing *European Management Journal*, 13(2): 193–200
- Hertveldt, B., Kegels, C., Michel, B., Van den Cruyce, B., Verlinden, J. & Verschueren, F. (2005). Déterminants de la localisation internationale, avec application aux secteurs Agoria [Working Paper 16-05]. Bureau Fédéral du Plan, Analyses et prévisions économiques, Bruxelles. Translated from French by Laura Sauvageot
- Hirsch, S. (1976). *An International Trade and Investment Theory of the Firm*. Oxford Economic Papers, 25–70
- Hirsjärvi, S., Remes, P., Sajavaara, P. (2001) Tutki ja kirjoita. Kustannusosakeyhtiö Tammi, Helsinki p. 128
- Holsti, O. R. (1969) *Content analysis for the social sciences and humanities*.
- Hotz-Hart, B. (2000) Innovation networks, regions and globalization. *The Oxford Handbook of Economic Geography*, 439–442
- Howells, J. (1990) The internationalization of R & D and the development of global research networks. *Regional Studies*, 24(6), 495-512.
- Hu, A. G. (2007) Technology parks and regional economic growth in China, *Research Policy*, vol. 36, p. 76-87.
- Hymer, S. H., (1976) *The International Operations of Multinational Firms: A Study of Foreign Direct Investment*. MIT Press, Boston.
- Håkanson, L., & Zander, U. (1988). International management of R&D: the Swedish experience. *R&D Management*, 18(3), 217-226.
- Håkanson, L., & Nobel, R. (1993). Determinants of foreign R&D in Swedish multinationals. *Research Policy*, 22(5), 397-411.
- Håkanson, L., Granstrand, O., & Sjölander, S. (Eds.). (1992). *Technology Management and International Business: Internationalization of R & D and Technology*. Wiley.
- Hägerström, M. (2010) *Buiding Partnerships in the Russian Business Environment: Alternatives for Internationalizing Finnish ICT SMEs*. Master's thesis, Turku School of Economics.
- Hätönen, J. & Eriksson, T. (2009). 30+ years of research and practice of outsourcing – Exploring the past and anticipating the future. *Journal of International Management*, 15(2), 142–155.
- Iansiti, M., (1993) Real-world R&D: jumping the product generation gap. *Harvard Business Review*, May – June 1995, p.138 – 147.

- IMAP (2011). Pharma & Biotech Industry Global Report 2011. An IMAP healthcare report
- Ito, B. Tomiura, E. & Wakasugi, R. (2007). Dissecting Offshore Outsourcing and R&D: A Survey of Japanese Manufacturing Firms. RIETI Discussion Paper Series 07-E -060
- Johne, F. A. (1984) How experienced product innovators organize. *Journal of Product Innovation Management*, 1(4), 210-223.
- Kay, N. M. (1979). *The Innovating Firm: A Behavioral Theory of Corporate R & D*. London: Macmillan.
- Kerr, D. J., Knox, K., Robertson, D., Stewart, D. & Watson, R. (2008) *Clinical Trials Explained: A Guide to Clinical Trials in the NHS for Healthcare Professionals*, Wiley, Chichester, GBR, 9–13
- Krippendorff, K. (1989). *Content Analysis*.
- Kogut, B., & Chang, S. J. (1991). Technological capabilities and Japanese foreign direct investment in the United States. *The Review of Economics and Statistics*, 401-413.
- Kogut, B. and Zander, U. (1993) Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies* 24, 625 – 645.
- Kortteinen, M., (1982) Lähio. Otava, Helsinki..296
- Kotabe, M., & Mudambi, R. (2009) Global sourcing and value creation: opportunities and challenges. *Journal of International Management*, 15(2), 121-125.
- Kuemmerle, W. (1999). The drivers of foreign direct investment into research and development: an empirical investigation. *Journal of international business studies*, 1–24.
- Kuemmerle, W. (1999a/b). Foreign direct investment in industrial research in the pharmaceutical and electronics industries—results from a survey of multinational firms. *Research Policy*, 28(2), 179-193.
- Kuemmerle, W. (1998). Strategic interaction, knowledge sourcing and knowledge creation in foreign environments—an analysis of foreign direct investment in R&D by multinational companies. *Managing strategically in an interconnected world*, Hitt et al (eds). Chichester: Wiley.
- Kuemmerle, W., 1997. Building effective R&D capabilities abroad. *Harvard Business Review*. March – April, pp. 61 – 70.
- Kvale, S. (1996). The interview situation. *Interviews. An Introduction to Qualitative Research Interviewing*, 124-143.
- Kyngäs, H., & Vanhanen, L. (1999). Content analysis as a research method. *Journal of Nursing Science*, 11(1), 3-12

- Lall, S. (1979). The international allocation of research activity by US multinationals. *Oxford Bulletin of Economics and Statistics*, 41(4), 313-331.
- Lall, S. (1980). Monopolistic advantages and foreign involvement by US manufacturing industry. *Oxford Economic Papers*, 32(1), 102-122.
- Lamin, A., & Livanis, G. (2013). Agglomeration, catch-up and the liability of foreignness in emerging economies. *Journal of International Business Studies*.
- Lehtinen, E. (1991). Ihminen tutkimuskohteena. Operationaalistamisen ongelmista. Teoksessa L. Syrjälä & J. Merenheimo (toim.) *Kasvatustutkimuksen laadullisia lähestymistapoja*. Oulun yliopiston kasvatustieteiden tiedekunnan opetusmonisteita ja selosteita, 39(1991), 11-31.
- Leifer, R., & Triscari, T. (1987). Research versus development: differences and similarities. *Engineering Management, IEEE Transactions on*, (2), 71-78.
- Lemmetyinen, Arja (2010) *The Coordination of Cooperation in Tourism Business Networks*. Doctoral dissertation, Turku School of Economics, Finland.
- Lewin and Peeters, 2006 Katso mikä
- Lewin, A. Y., Massini, S., & Peeters, C. (2009). Why are companies offshoring innovation&quest. The emerging global race for talent. *Journal of International Business Studies*, 40(6), 901-925.
- Lewin and Peeters (2006) Lewin, A. Y., Massini, S., & Peeters, C. (2009). Why are companies offshoring innovation? The emerging global race for talent. *Journal of International Business Studies*, 40(6), 901-925.
- Lewin, A. Y., & Peeters, C. (2006). Offshoring work: business hype or the onset of fundamental transformation?. *Long Range Planning*, 39(3), 221-239.
- Peeters, C., & Lewin, A. (2006). The top-line allure of off-shoring (No. 2013/9041). ULB--Universite Libre de Bruxelles.
- Lewin, A. Y., & Peeters, C. (2006). The top-line allure of offshoring. *Harvard Business Review*, 84: 22–24.
- Lewin, A. Y., and Couto, V. (2007) *Next generation offshoring: The globalization of innovation: 2006 Survey report*. Duke center for international business education and research (CIBER).
- Li, J. & Zhong, J. (2003) Explaining the Growth of International R&D Alliances in China *Managerial Decision Economics* 24: 101–115
- Lincoln, Y. S., and Guba, E. G. (1985) Establishing trustworthiness. *Naturalistic inquiry*, 289-331.
- Lundin, N., & Schwaag Serger, S. (2007). Globalization of R&D and China—empirical observations and policy implications (No. 710). IDEA Paper provided by Research Institute of Industrial Economics in its series Working Paper Series with number 710.

- Macher, J. T., Moverly, D. C. (eds). (2008). *Innovation in Global Industries: U.S. Firms Competing in a New World (Collected Studies)*. Introduction, 1–4, Board on Science, Technology, and Economic Policy (STEP), Washington D.C. The National Academies Press. http://books.nap.edu/openbook.php?record_id=12112&page=R1
- Mack, N., Woodsong, C., MacQueen, K. M., Guest, G. Namey, E, (2005) *Qualitative Research Methods: A Data Collector's Field Guide*. Family Health International, Research Triangle Park, North Carolina 27709, USA.
- Mansfield, E., Teece, D. and Romeo, A. (1979) Overseas research and development by U.S.-based firms. *Economica*, 46: 187-96.
- Manuel, S., Donald, D., & Phyllis, G. Y. (2000). Globalization of R&D enters new stage as firms learn to integrate technology operations on world scale. *Research Technology Management*, 43(1), 2.
- Markusen, J. R. (2005). Modeling the Offshoring of White-Collar Services: From Comparative Advantage to the New Theories of Trade and Foreign Direct Investment. Brookings Institution Press. In *Brookings Trade Forum Vol. 2005, No. 1*, pp. 1-23.
- Marshall, C., & Rossman, G. B. (1989). *Designing qualitative research* Sage. Newbury Park CA.
- Matsoukas, J Mavromoustakos, T (2002). *Drug Discovery & Design: Medical Aspects*, IOS Press, Amsterdam, NLD 07/2002, 229–294
- McEvily, S.K., Chakravarthy, B. (1999). Resource context and the returns of investments in R&D. In: Havlovic, S.J. (Ed.), *Proceedings of the Academy of Management Meetings 1999*.
- Medcof, J.W. (1997). A taxonomy of internationally dispersed technology units and its application to management issues. *R&D Management* 27 (4), 301–318.
- Mendez, A. (2003). The coordination of globalized R&D activities through project teams organization: an exploratory empirical study. *Journal of World Business*, 38(2), 96–109.
- Meyer-Krahmer, F., & Reger, G. (1999). New perspectives on the innovation strategies of multinational enterprises: lessons for technology policy in Europe. *Research Policy*, 28(7), 751-776.
- Miller, E. W. (1977). *Manufacturing: a study of industrial location*. Pennsylvania: Pennsylvania State University Press.
- Moncada-Paternò-Castello, P., Vivarelli, M., & Voigt, P. (2011). Drivers and impacts in the globalization of corporate R&D: an introduction based on the European experience. *Industrial and Corporate Change*, 20(2), 585–603.
- Ministry of Education P.R.C. (2003a) *Report on the Development of Countrywide Educational Undertaking in 2002*. Ministry report, Beijing.

- Ministry of Education P.R.C. (2003b) Short Introduction of Studying and Working Abroad. Ministry report, Beijing.
- Yin, R. (1998) The abridged version of case study research. In: Blickman, L. and Rog, D.J. (eds), Handbook of Applied Social Research.
- Moos, W.H. (2001). The Intersection of Strategy and Drug Research, in: Taylor, J., B. and Triggle, D., J. Comprehensive Medicinal Chemistry II, Elsevier, Oxford, 2007, 1–84
- Mudambi, R. (2007). Offshoring: economic geography and the multinational firm. *Journal of International Business Studies*, 38(1), 206.
- Newman, D. J., Cragg, G. M., & Snader, K. M. (2000). The influence of natural products upon drug discovery. *Natural product reports*, 17(3), 215-234.
- Norwood, J., Carson, C., Deese, M., Johnson, N. J., Reeder, F. S., Rolph, J. E., & Schwab, S. (2006). Off-shoring: an elusive phenomenon. Report of the Panel of the National Academy of Public Administration for the U. S. Congress and the Bureau of Economic Analysis. p. 8-35 Recovered in May 10, 2012, from <http://www.napawash.org/2006/1360-off-shoring-an-elusive-phenomenon.html>
- National Science Foundation. 1990a. Research and development in industry, NSF 90-319. Washington, D.C.
- National Science Foundation, (1990b) Future Scarcities of Scientists and Engineers: Problems and Solutions, Division of Policy Research and Analysis. Washington, D.C., Wolpe Hearing Proceedings, p. 990-1087.
- Niosi, J. (1997). The globalization of Canadian R&D. *Management International Review*, 37(4): 387–404.
- Nieto, M. J., & Rodríguez, A. (2011). Offshoring of R&D: Looking abroad to improve innovation performance. *Journal of International Business Studies*, 42(3), 345–361.
- Nonaka, I., Takeuchi, H. (1995). *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York. p. 197–2010
- Factbook, O. (2008). *OECD Factbook 2008: Economic, Environmental and Social Statistics*.
- OECD (1998) *Internationalization of Industrial R&D: Pattern and Trends*. Paris.
- OECD (2003) *OECD Investment Policy Reviews – China: Progress and Reform Challenges*. Paris: OECD Publications Service.
- Oshri I., Kotlarsky J. & L.P. Willcocks. (2009). ‘The Handbook of Global Outsourcing and Offshoring’, Macmillan, London, 2, 4, 9

- Patel, P., Pavitt, K. (1992). Large firms in the production of the world's technology: an important case of non-globalization. In: Granstrand, O., Hakanson, L., Sjolander, S. (Hrsg.), *Technology Management and International Business: Internationalization of R&D and Technology*. Chicester, 53–73.
- Paul, S. M., Mytelka, D. S., Dunwiddie, C., T. Persinger, C., C., Munos, B. H., Lindborg, S. R. & Schacht, A. L. (2010). How to improve R&D productivity: the pharmaceutical industry's grand challenge. *Nature reviews drug discovery* (9): 203–214
- Pearce, R. D. (1989) *The internationalisation of research and development by multinational enterprises*. New York, US: St. Martin's Press.
- Pearce, R. (2005). The globalization of R&D: key features and the role of TNCs. In *Proceedings of the Expert Meeting Globalization of R&D and Developing Countries, United Nations Conference on Trade and Development, Geneva, 29-42*
- Perrow, C. (1967). A framework for the comparative analysis of organizations. *American sociological review*, 194-208.
- Petrella, R. (1992). Internationalization, multinationalization and globalization of R&D: Toward a new division of labor in science and technology?. *Knowledge and Policy*, 5(3), 3-25.
- Phene, A., and Almeida, P. (2008). Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies*, 39(5), 901-919.
- Pisano, G. P. (1990) The R&D boundaries of the firm. *Administrative Science Quarterly*, 35: 153-176
- Pitkäranta, K. (2010) *Laadullisen tutkimuksen tekijälle*. Työkirja Satakunnan AMK, 86–89
- Popper, K. R. (1972). *Objective knowledge: An evolutionary approach*. Oxford: Clarendon Press, 341–345
- Porter, M. E. (1986). *Changing patterns of international competition*. University of California. 18-20
- Quinn, J. B.. 1969. Technology transfer by multinational companies. *Harvard Business Review*, November-December: 147-61.
- Quinn, J. B. & Hilmer, F. G. (1994) *Strategic Outsourcing*, MIT Sloan Management Review, reprint 3544, 35(4), 43–55
- Raukko, Mélanie (2009) *Organizational commitment during organizational changes: A longitudinal case study on acquired key employees*. *Baltic Journal of Management*, Vol.4 (3), 331 – 352.
- Rivoli, Pietra & Eugene Salorio. 1996. Foreign direct investment and investment under uncertainty. *Journal of International Business Studies*, 27: 335-57.

- Reddy, P. and Sigurdson, J. (1997) Strategic location of R&D and emerging patterns of globalization: the case of Astra Research Center India, *International Journal of Technology Management*, 14, pp. 344 – 361.
- Reddy, P. (1997) New trends in globalization of corporate R&D and implications for innovation capability in host countries: a survey from India. *World Development*, 25(11), 1821–1837
- Reddy, P. (2002) *The Globalization of Corporate R & D: Implications for Innovation Systems in Host Countries*. Routledge.
- Roberts, E. B., (1995a) Benchmarking the strategic management of technology: I. *Research Technology Management* 38(1):44 –56.
- Roberts, E. B., (1995b) Benchmarking the strategic management of technology: II. *Research Technology Management* 38(2):18 – 26.
- Robinson, Richard D. 1988. *The international transfer of technology*. Cambridge, MA: Ballinger.
- Ronstadt, Robert. 1977. *Research and development abroad by US multinationals*. New York, NY: PraegerIndicators: Basic Statistical Series Volume B. Paris: OECD.
- Ronstadt, R. C. (1978). International R&D: the establishment and evolution of research and development abroad by seven US multinationals. *Journal of International Business Studies*, 7–24
- Roussel, P., Saal, K. & Erickson, T. (1991). *Third Generation R&D Managing the Link to Corporate Strategy*. Boston, MA.
- Rubin, H., J. and Rubin, L., S. (1995). *Qualitative interviewing. The art of hearing data*. Thousand Oaks, Sage. 5–6.
- Ruffolo, R. R. (2006). Why has R&D productivity declined in the pharmaceutical industry?. *Expert opinion on drug discovery*, 1(2), 99.
- Rugman, A. M., & Verbeke, A. (2003). Extending the theory of the multinational enterprise: Internalization and strategic management perspectives. *Journal of International Business Studies*, 34(2), 125–137.
- Schumpeter, J. A. (1942). *Socialism, capitalism and democracy*. Harper and Brothers.
- Sen, F. and Rubinstein, A.H. (1989). External technology and in-house R&D's facilitative role, *Journal of Product Innovation Management* 2, 123–138.
- Serapio, M.G. and Dalton, D.H. (1999) Globalization of industrial R&D: an examination of foreign direct investments in R&D in the United States. *Research Policy*, 28(2–3):303–316
- Song, J., & Shin, J. (2008). The paradox of technological capabilities: a study of knowledge sourcing from host countries of overseas R&D operations. *Journal of International Business Studies*, 39(2), 291–303.

- Shah, S. (2003). Globalization of clinical research by the pharmaceutical industry. *International Journal of Health Services*, 33(1), 29-36.
- SHPMCC, (23.5.2013 15.45) Shanghai Food and Drug Packaging Material Control Center, <http://www.shpmcc.com/en/index.html>
- Stemler, S. (2001). An overview of content analysis. *Practical assessment, research & evaluation*, 7(17), 137–146. Retrieved in August 22, 2013 from <http://PAREonline.net/getvn.asp?v=7&n=17>
- Sun, Y., von Zedtwitz, M. and Simon, D., F. (2007) Globalization of R&D and China: An Introduction *Asia Pacific Business Review*, 13(3): 311–319, July
- Sun, Y., & Wen, K. (2007). Uncertainties, imitative behaviours and foreign R&D location: explaining the over-concentration of foreign R&D in Beijing and Shanghai within China. *Asia Pacific Business Review*, 13(3), 405-424.
- Su, Y. S. (1994). Strategic Positioning of Taiwan in the Global Biotechnology Value Chain. *Pharmaceuticals*, 392(12), 18
- Sydow, J., 1992. *Strategische netzwerke: evolution und organisation*. Neue Betriebswirtschaftliche Forschung, Band 100, Wiesbaden: Gabler.
- Sykes, W. (1990) Validity and reliability in qualitative market research: A review of the literature. *Journal of the Market Research Society*, Vol. 32 (3), 289–328.
- Terpstra, V. (1977) International product policy: The role of foreign R&D. *Columbia Journal of World Business*, Winter: 24-32.
- Teece, D.J., 1976. *The Multinational Corporation Cost of International Technology Transfer*. Cambridge, MA. USA
- Thomson Reuters (21.12.2011 22.52) China tops U.S, Japan to become top patent filer <http://www.reuters.com/article/2011/12/21/us-china-patents>
- Thomson Reuters (16.12.2011 19.28) Manufacturing can thrive but struggles for respect <http://www.reuters.com/article/2011/12/14/us-usa-manufactur...>
- Tornatzky, L. G., Eveland, J. D., Boylan, M. G., Hetzner, W. A., Johnson, E. C., Roitman, D., and Schneider, J. (1983). The process of technological innovation: reviewing the literature. Productivity Improvement Research Section. Division of Industrial Science and Technological Innovation, National Science Foundation, Washington (DC), 83-37. Tuomi and Sarajärvi, 2004
- Twiss, B. (1980) *Management of technological innovation*.
- Uzunidis, D. & Boutillier, S. (2012). "Globalisation de la R&D et innovation collaborative : l'expansion des frontières de la firme globalization of R&D and collaborative innovation: the expansion of the firms border" Working Papers 255, Laboratoire de Recherche sur l'Industrie et l'Innovation. ULCO / Research Unit on Industry and Innovation.
- Vallance, P., and Levick, M. (2007) Drug discovery and development in the age of molecular medicine. *Clinical pharmacology and therapeutics*, 82(4), 363–366.

- Van de Ven, A. H, Delbecq, A. L., & Koenig, R., Jr. (1976). Determinants of coordination modes within organizations. *American Sociological Review*, 41(2), 322—338.
- Vernon, R. (1977). *Storm over the Multinationals: The Real Issues*, London: Macmillan p. 41-5.
- Varadarajan, R. (2009) Outsourcing: Think more expansively *Journal of Business Research* 62: 1165–1172
- Von Braun, C.-F. (1995). *Der Innovationskrieg: Ziele und Grenzen der industriellen Forschung und Entwicklung*. Munchen, Translated from German by Laura Sauvageot
- Von Zedtwitz, M., & Gassmann, O. (2002). Market versus technology drive in R&D internationalization: four different patterns of managing research and development. *Research policy*, 31(4), 569–588
- Von Zedtwitz, M. (2004). Managing foreign R&D laboratories in China. *R&D Management*, 34(4), 439–452.
- Von Zedtwitz, M., Gassmann O., Boutellier, R. (2004). Organizing global R&D: challenges and dilemmas *Journal of International Management* 10: 21 – 49
- Von Zedtwitz, M. (2005). International R&D strategies of TNCs from developing countries: the case of China. In *Globalization of R&D and Developing Countries* (pp. 17-40). UNCTAD. 29, 135, 141–142
- Welch, L., s. and Luostarinen, R., K., (1988) Internationalization: Evolution of a concept. *Journal of General Management* 14(2):34-55
- Westhead, P., Wright, M., and Ucbasaran, D. (2007) Issues surrounding the internationalization of SMEs: implications for policy makers and researchers. In the book Susman, G., I. (2007) *Small and Medium-Sized enterprises and the global economy*. Edward Elgar Publishing Inc. Northampton, Massachusetts, USA
- Wheelwright, S. C., and Clark, K. B. (1994) Accelerating the design-build-test cycle for effective product development. *International Marketing Review*, 11(1), 32-46.
- Withey, M., Daft, R. L. and Cooper, W. H. (1983) Measures of Perrow's work unit technology: An empirical assessment and a new scale. *Academy of Management Journal*, 26(1), 45-63.
- Xinhua, China.org.cn (27.10.2010) CPC sets targets for 12th Five-Year Program Xinhua, http://www.china.org.cn/china/2010-10/27/content_21214648.htm
- Xue, L. and Wang, S. (2001) Globalization of R&D by multinational corporations in China: an empirical analysis. EAP Report Memorandum #01–06, National Science Foundation, Tokyo.

- Yin, R., K. (2003) Case study research – design and methods. Applied Social Research Methods Series, 3rd ed., Vol. 5, Sage Publications, Thousand Oaks, CA.
- Zeng, Z., Xiong, X. L. (2008) Fragmentation, Production Cost and Offshoring: General Theory and Evidence of America's Offshoring to China and India, The Journal of World Economy, vol. 31, n12, p. 37-47.
- Zhang, Y., Li, H., Hitt, M. A., & Cui, G. (2007). R&D intensity and international joint venture performance in an emerging market: moderating effects of market focus and ownership structure. Journal of International Business Studies, 38(6), 944-960.
- Åkerblom, M., & Luhtala, T. (2006). Ideas for New Indicators on Globalization of R&D. Statistics Finland.
- Ödman, P. (1979). Tolkning, förståelse, vetande — Hermeneutik i teori och praktik. [Interpretation, understanding, knowledge — The theory and practice of hermeneutics]. Almqvist & Wiksell Förlag AB, Stockholm.