Motivations and barriers of foreign R&D activities in China

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The continued growth of the Chinese economy accompanied with the expansion of international investment in China has led to an increase in foreign research and development (R&D) activities in the country. Aside from the rising importance of R&D internationalization, research on foreign R&D in China has been neglected in the past due to its emerging status. In this article we examine drivers and barriers for conducting R&D in China. The focus of our research is on transnational companies typically characterized by decentralized R&D activities. Our research is mainly based on qualitative interviews with senior R&D managers. The success of foreign R&D activities in China strongly depends on the realistic estimation of its advantages and the proper identification and handling of barriers.

1. Introduction

China, the world's largest emerging economy, has become the most important investment destination for transnational companies (TNCs). In 2002 China overtook the USA as the biggest recipient of foreign direct investment, rising to an estimated US$53 billion (Reuters, 2003). This clearly reflects the importance of the country's position as a major production site and marketplace for TNCs. It also highlights international investors' support for China's entry into the World Trade Organization (WTO) in November 2001. Accompanied by a significant inflow of foreign direct investment, more and more TNCs are increasing their tendency towards and involvement in local R&D activities. Equity-based R&D commitments are only part of TNCs' R&D endeavours in China. Most TNCs realize that their international expansion is a process of small steps to be taken in order to adapt gradually to the host country's unique environment. Previous research has shown that TNCs prefer to invest cautiously and benefit from experiences and knowledge gained from their prior operations and build upon an existing network of foreign value-added activities (Kogut, 1983; Li, 1995). This behaviour is in line with the results of recent research (Li and Zhong, 2003) which identified 276 international R&D alliances in China between 1995 and 2000. The researchers found that non-equity-based R&D co-operative agreements outweighed equity-based R&D joint ventures.

Although one cannot ignore the increasing significance of foreign R&D activities in China, research in the area of R&D management in China is still mostly uncharted territory. In order to facilitate understanding of this recent phenomenon, our paper aims to answer three questions: (1) what are the most important motivations behind establishing R&D activities in China? (2) What kinds of barriers are TNCs' R&D managers facing? and (3) what are the managerial implications?

2. Literature review

Although R&D is usually one of the last objectives of an internationalization strategy (Mansfield *et al.*, 1979; Pearce, 1989), the process of R&D internationalization has continued in earnest. For example, between 1997 and 1998, US foreign R&D spending increased by 28%, from $17 billion to $22 billion. Meanwhile, US companies' overseas R&D spending reached $17 billion in 1999, a growth rate of 25% (after adjusting for inflation) from 1997 (National Science Board, 2002). R&D internationalization in the 1980s and 1990s was largely restricted to technology-based multinational companies. As some researchers have stated, conducting R&D overseas helps companies obtain local knowledge (Howells, 1990a; Kogut and Chang, 1991; Florida, 1997). Companies strive to locate their R&D activities at centers of technological excellence, regions characterized by a high rate of new technology output that possess particularly advantageous spillover potential. It does not come as any surprise that the pioneers of R&D internationalization are high-tech companies operating in small markets that face a scarcity of resources in their home countries (Gassmann and von Zedtwitz, 1999). Companies such as General Electric and General Motors in the USA, Toyota and Fujitsu in Japan, and Daimler-Benz in Germany all had large home markets and a substantial domestic R&D base; meaning they had less pressure to internationalize their R&D activities. However, increased competition from within and outside their industries in recent years forced these companies to source technological knowledge on a global scale. Other researchers found that R&D internationalization is positive in helping companies to better adapt their products to the needs of local markets (Howells, 1990b; Håkanson and Nobel, 1993a, b). As firms establish production facilities overseas and increase product complexity, R&D facilities near production sites are needed to give technical support to localized manufacturing. These two types of international R&D investments have been framed by Kuemmerle (1999) as home-base-augmenting (HBA) and home-base-exploiting (HBE). The majority of research on R&D internationalization has focused on the following regions: the USA, Japan and Western Europe. Nevertheless, recent developments of R&D internationalization have tended to take place outside of these traditional regions. While most R&D laboratories are concentrated in the triad countries, new R&D sites are now being created in the newly industrialized economies of South-East Asia.

Within the broad field of R&D management in China, we have identified the following areas under scholarly investigation. At the beginning of China's economic opening, some scholars focused on the structure of national Science and Technology (S&T) systems and state owned industrial R&D (see e.g., Fischer, 1983; Fischer and Farr, 1985; Jin and Porter, 1988). Although these findings revealed significant obstacles existing in the country's innovation system, the potential that China will experience rapid advancement is considered to be high, given the confluence of the worldwide information revolution, the opening of new markets, and China's readiness for economic expansion (Jin and Porter, 1988). Against the background of China's increasing transformation from a centrally planned to a market-based economic system, some researchers, such as Brockhoff and Guan (1996), have focused more attention on how Chinese SOEs can overcome structural problems in managing technological innovation. Very little research has touched upon managerial aspects of managing R&D in China. De Boer, Gan and Shan (1998) have looked at critical issues facing local R&D managers such as shortage of funds, ageing R&D staff, increasing competition and rapid development of technology. De Boer *et al.* suggest various solutions, such as sending Chinese R&D managers abroad for exchange, forging international co-operation and implementing Western R&D management theory in China; these measures could all help Chinese R&D managers to tackle the critical issues faced above.

Recently an increasing number of TNCs has recognized China as a preferred place to conduct offshore R&D activities. Accompanied by the growth of foreign R&D in China, some researchers have made an effort to outline the pattern and characteristics of foreign R&D activities in China (see Xue and Wang, 2001; Li and Zhong, 2003). These studies found that R&D investments tend to be concentrated within high-technology industries such as software, telecommunications, biotechnology and chemicals. However, this research is conducted to explore the motivation behind the reasons why TNCs invest R&D in China, and the barriers they face when undertaking such an endeavour. Our research aims to identify the most significant motivations and barriers of foreign R&D activities in China, which should be taken into account by R&D managers of TNCs. Based on our findings, we will then provide several relevant managerial implications.

3. Research methodology and data sample

Given the exploratory nature of our focus, research is mainly based on case studies, results from previous research, research of official Chinese publications and Internet sites, along with interviews with R&D managers with previous experience in China. The case study is widely considered to be an appropriate method to navigate unclear boundaries between phenomenon and context in the early stages of research. Particularly when the research questions examine a contemporary event, and when there is little or no control over behavioral events. This is especially true in the field of management, where case studies provide a strong relevance to problems in practice (Yin, 1998).

Our case studies have generally relied on the primary data source of in-depth expert interviews and secondary data such as company press releases and Internet research. Between 2002 and 2003, we conducted 18 interviews with senior R&D managers involved in R&D activities in China. This kind of triangulation allows us to minimize the bias of personal perspective and enhance the validity of the information. To combine the advantages of unstructured and semi-structured interview methods, we started with open-ended questions, followed by a structured questionnaire protocol. Besides asking formal questions regarding the companies' motivations and barriers of their R&D activities in China, the interviewees were also strongly encouraged to provide related examples from their daily business, including current projects.

The intention of the interviews was to identify relevant factors of motivations and barriers to TNCs' R&D investments in China. The companies interviewed came from automotive, machinery, IT and software industry: ABB, Siemens, SIG, Schindler, Microsoft, GM, VW, Siemens VDO Automotive. The companies were all based in Western countries, and each had a significant and traceable history in China.

4. Characteristics of TNCs' R&D activities in China

At the early stages of China's economic liberalization, production-based FDI was the main focus driver of China's economic growth and modernization. Foreign firms investing in China engaged only in limited levels of R&D activity. According to the OECD (2002), only 1% of foreign companies had R&D departments, half of these did not receive stable funding, one-third did not perform R&D regularly, and nearly two in five lacked the necessary experimentation and testing equipment. In recent years, more TNCs have identified China as a preferred place to conduct offshore R&D activities. An analysis of the 2003 official statistics of the Ministry of Science and Technology provided clear evidence of increased awareness. Between 1987 and 2002, 65 transnational companies had established 82 R&D organizations (equity-based) in China (China S&T Statistics, 2003). In recent years, this awareness has grown; between 1988 and 1992 only an average of 0.8 new R&D units per year were established in China, while between 1998 and 2002 this number had grown to 8.4 units. While this statistic might not reveal the exact dimension of foreign R&D activities in China (e.g., Motorola, which has 18 R&D centers and 7 more under construction, is only counted once in the statistic) – one can clearly recognize the tendency for longitudinal growth. This fact is further underlined by several actual considerations of China as a place for future R&D locations by our interview partners.

The regional distribution of foreign R&D activities reveals TNCs' clear preference concerning their R&D sites in China. The majority of the TNCs' R&D centers are based in the two most economically important cities of China, Beijing and Shanghai (Li and Zhong, 2003; China S&T Statistics, 2003). The most attractive features of these two cities are highly qualified human resources, well-developed infrastructure, numerous industrial sectors and high-tech parks, and mature local scientific communities including top-class universities and research institutes. According to China Science and Technology (S&T) statistics, 65.9% of R&D centers are embedded in TNCs' joint venture in China, while the remainder of the TNCs' R&D sites is registered as wholly-owned enterprises. A survey of China S&T statistics disclosed that the tendency for wholly-owned R&D centers is positively related to the technological sensitiveness of TNCs' business field, since wholly-owned R&D centers protect knowledge and prevent unwanted technology transfer. Findings of our interviews also support this result. The computer and telecommunications industries are driving R&D investment in China. Other important industries with R&D investment in China include chemical, petrochemical, biotech, pharmaceutical, automotive, transportation and power generation equipment (Xue

and Wang, 2001; Li and Zhong, 2003; China S&T Statistics, 2003). These TNCs typically come from the triad regions. Most of them are from North America, especially from the USA, followed by the European Union and Japan. A further significant group of R&D investors comes from Greater China, specifically Hong Kong and Taiwan (Li and Zhong, 2003; China S&T Statistics, 2003).

A strong driver for foreign R&D is the market. If the company's business requires local product adaptation and intensive customer cooperation, it is likely that local development units will be established (e.g., von Zedtwitz and Gassmann, 2002, p. 580). Due to the sheer size and specific requirements of the Chinese market, this implies that the majority of TNCs' R&D activities in China are market driven and development oriented. For example, software and mobile phone companies such as Microsoft or Nokia set up development centers to develop a localized user interface using the Chinese language. Research results of Li and Zhong (2003) revealed that between 1995 and 2000, two-thirds of TNCs' R&D alliances in China (including equity-based and non-equity-based alliances) are development oriented.

Nevertheless, several TNCs' laboratories have added sufficient resources to build specific leading-edge platforms, transforming the lab into a competence center for the entire global enterprise, dedicated to fundamental research. For instance, Microsoft set up its research center in Beijing in 1998, conducting research on topics such as next generation multimedia and Chinese PC technology (Gelb, 2000). Siemens and IBM have long established corporate research labs in Beijing.

5. The case of Siemens VDO Automotive

As an introduction to the motivations and barriers of foreign R&D in China, this section will use Siemens VDO Automotive as a practical example and briefly illustrate its experiences in China. Siemens has a Corporate Research lab in Beijing, employing 25 people. The mission is to contribute to corporate research (active research), to handle intellectual property issues of Siemens in China (local IP presence), and to promote Siemens standards in the early and emerging phase before dominant designs have been established (market development). In addition to this corporate R&D activity, Siemens VDO Automotive, a wholly owned subsidiary of Siemens, is in the evaluation process of establishing a development center in China.

Siemens VDO Automotive has 137 business locations worldwide with close to 43,600 employees in the all-important automotive market. Siemens VDO is a supplier of automotive products, with the 16 product divisions that can be construed as profit centers, all embedded in a matrix organization. More than 70% of the product range is less than 3 years old, which highlights the emphasis on innovation. The Asia strategy of Siemens VDO is to expand their position and double turnover in Asia by 2005/2006. China is considered to be a strategic and important market to achieve this goal. In China, Siemens VDO started its activities in 1995, and has since invested in five operating units. In the 1990s, establishing joint ventures was mandatory to enter the Chinese market. Since this time, two of the units have turned to wholly-owned enterprises. Local production facilities of Siemens VDO in China mostly manufacture products that were developed in Europe. The majority of Siemens VDO's customers are international auto manufacturers such as Volkswagen, BMW, and Hyundai. Until now, all R&D projects have been development and application oriented, with no research activities at all. Due to the lack of local development capacity, these projects are supported by and consist of members of R&D teams based in other countries such as Korea or Australia.

Motivations and barriers of on-site R&D activities

The management of Siemens VDO is aware of the importance of the Chinese market and the strategic significance of creating competitive advantages in China. For Siemens, there are several reasons to carry out local development. First, with new models continually being introduced into the Chinese car market, it will be vital to keep their product development in line with model releases from different car manufacturers. In order to respond quickly to customer demands in the future, it will not be sufficient to conduct development activities through headquarter's R&D department. Second, there are cost saving potentials due to low engineering man-hour costs in China. Cost savings can be achieved from products developed abroad, (e.g. in Germany) which are sometimes over-engineered in regards to the lesser requirements of local customers. Third, engineering support to local customers will be easier to follow up on than with a central R&D department. Fourth, due to specific local

conditions in which automotive products are operating, some of the development activities must be conducted on-site. Examples of such activities include local air and climatic conditions and gas quality needs and development work in power train adjustment. As well, on-board infotainment services need localized adjustments with respect to culture and language. At this stage the volume of products that could be developed locally is still inadequate to achieve sufficient economies of scale. One major reason for this is the congested car market in China. About 2400 companies are involved in the manufacturing of vehicles. At present there are 120 complete vehicle plants, of which 12 have a yearly output exceeding 10,000 units, and only three have a production capacity exceeding 300,000. According to industry experts, an enterprise with an annual output of less than one million is not competitive in the international market. One further dilemma that is a general concern for all automotive R&D managers in China is the lack of experienced automotive specialists. Although there are several universities in China with automotive departments, given the increasing demand for automotive specialists, there is still an insufficient number of qualified automotive engineers when compared to international standards.

R&D co-operation as an option

The management of Siemens VDO is aware that the aforementioned obstacles set limitations on direct investment in R&D activities. Therefore the form of co-operation is considered as an alternative means of reliance in order to ensure competitive advantage. What is notable is that most of the domestic automotive companies are not able to provide technological benefit to Siemens VDO through their relationship. Within the automotive industry, co-operation in China will mainly offer advantages with respect to development time reduction; joint use of resources and facilities, regional market knowledge, and market barriers to entry creation.

In our case there are two kinds of potential co-operation partners: universities and automotive companies along the supply chain. In the Siemens VDO case, universities are preferable co-operation partners primarily for two reasons: first, the contact with a university will be seen as a good source of qualified automotive engineers. Second, universities might possess testing facilities crucial for product development, such as an engine testing facility. Both reasons are resource-based. Siemens VDO has a strong exchange and co-operation agreement with the automotive faculty of Changchun University of Science and Technology. Another potential source for co-operation partners is Chinese automotive firms along the supply chain (vertical integration). They can help to attract customers and build long-term business relationships with key customers in order to create market entry barriers. According to the interviewed experts, competitors will definitely not be considered as cooperation partners due to apprehension of unwanted technology transfer.

6. Motivations for establishing R&D in China

6.1. General motivations of foreign R&D

Prior to studying TNCs' motivations for establishing R&D in China, we shall briefly outline the results of earlier research on basic motivations and drivers for conducting R&D abroad. Different approaches have been used to classify motivations for R&D internationalization. One approach broadly distinguishes between demand-oriented and supply-oriented drivers for R&D internationalization (see Granstrand, Håkanson and Sjölander, 1993; Dunning and Narula, 1995; OECD, 1998). Demand-oriented motivation factors include the special needs of the local country/market, which require modifications of the firm's products; or host country restrictions, such as local content requirements, tolls, import quotas, and fulfilment of standards. Supply-oriented factors include highly sophisticated foreign scientific infrastructure (e.g., new regional technological competence centres such as Sillicon Valley, Prato or Modena), which takes advantage of host country scientific and knowledge inputs and accesses cutting-edge technology. Availability of well-educated local R&D specialists, ideally combined with low R&D personnel costs are further supply-oriented incentives to establish R&D abroad. A third group of motivations, environmental motivation factors, is mentioned by Granstrand *et al.* (1992).

In a more refined classification scheme, Beckmann and Fischer (1994) identified five categories of R&D internationalization drivers (input-oriented, output-oriented, external, efficiency-oriented and political/social-cultural). This classification has been used to classify drivers of R&D internationalization whereas input- and

Table 1. Important motivations for TNCs' R&D establishment in China.

Input-oriented motivations	Performance-oriented motivations
• Availability of highly qualified personnel • Tapping informal networks and knowledge sources • Local pockets-of-innovation	• Customer and market-specific development • Adaptation to local production processes • Cost advantages
Business-ecological motivations	
• Government policy • Continuing economic growth and unique market size • Peer pressure	

output-oriented factors are in principle in accordance with the supply- and demand-oriented view. The three other categories such as external, efficiency-oriented, and political/social-cultural factors reveal the multifarious character of motivations for R&D internationalization.

Based on our research interviews and literature analysis, we have relied on this scheme as a preliminary framework to examine the specific motivations for establishing R&D in the Chinese context. Since the motivation factors we have identified within the Chinese context do not expediently conform to the scheme of Beckmann and Fischer (1994), we have merged output and efficiency-oriented motivation factors into performance-oriented motivation factors and external and political/social-cultural into business-ecological motivation factors (see Table 1).

6.2. Input-oriented motivations

Availability of qualified personnel. Amongst the input-oriented motivations for establishing R&D in China, the huge human resource potential is of great importance. In 2002, 2.5 million students graduated from the country's 3000 universities and colleges including 14,000 PhDs, ranking China third behind the USA (approx. 40,000) and Germany (approx. 30,000). China also produced more than 66,000 masters students in 2002 (Ministry of Education PRC, 2003a). Many top-flight universities such as Tsinghua, Beijing, Zhejiang and Fudan produce highly qualified graduates in disciplines such as mathematics and natural sciences. Aside from domestic graduates, more than 580,000 Chinese students were dispersed among 100 countries and regions worldwide for studying purposes between 1978 and 2002, with 150,000 of them returning to China (Ministry of Education PRC, 2003b). The majority of students chose to immigrate into other countries after graduating. Hence, China has suffered from an outflow of talents (brain drain) to a great extent. In recent years, Chinese governments, at both national and local level, have introduced policies to induce highly skilled overseas Chinese to return to China (OECD, 2002). Increasing numbers of scientists and graduates have returned from abroad thanks to the enduring economic growth and improved opportunities in China. In 2002, more than 18,000 of the so-called 'returnees' came back to China, an increase of 47% compared to 2001 (Ministry of Education PRC, 2003b). These key people represent an additional pool of uniquely qualified human resources, and bring experience and knowledge from around the globe.

Tapping informal networks and information sources. In China, business success is heavily dependent on strong informal networks and relationships – the frequently cited 'GuanXi'. The establishment of a local R&D center enables a company to build and maintain informal networks with universities and local scientific communities, which can help TNCs to establish strategic partnerships and establish human resources for the long term. In addition, China's industrial development is at an emerging level and the economy is undergoing a transition from a planned to a market based system. Hence changes in industrial regulations, legislation and policies are all the more dynamic. Their on-site R&D activities and proximity to the government help TNCs to keep pace with changes in the dynamic Chinese environment, while also allowing them to achieve critical competitive advantages. Using local R&D to gather technology intelligence on local and international competition is yet another input-oriented motivation for TNCs' to conduct R&D activities in China.

Local pocket-of-innovation. Since Chinese policy makers seek to raise the level of China's industrial

production and increase competitiveness to an international level, special economic and other investment zones have been established and have become the main engine for growth in the Chinese economy. Notably, the High Technology Development Zones (HTDZ) or 'science parks' have been designed to lure researchers, entrepreneurs, foreign R&D centers and venture capitalists from around the world. As an example, Beijing's high-tech Zhongguancun area located northwest of the city is home to a large number of universities and scientific institutions including Tsinghua University, Beijing University and the Chinese Academy of Science. As a result, there are a number of start-up firms, foreign-capital firms and large-scale local firms that are seeking access to high potentials through building strong relationships with the universities. Furthermore, these pockets-of-innovation attract investors by providing space, advanced infrastructure, and high-tech facilities that they need along with financial incentives. As an example, the Chinese State Council and Beijing municipality both offer start-up firms located in Zhongguancun area tax-free operation for three years following their establishment, followed by a 50% discount for the next three years, and a 15% discount from the seventh year onwards, along with other tax incentives. Due to the substantial governmental support and geographical uniqueness, it is not surprising that several of our interview partners believe that these industrial and science parks will become centers of excellence in the future. Since more Chinese cities and regions are trying to capture the attention of TNCs by various incentives, more TNCs have invested outside of Beijing and Shanghai, the two established hubs of foreign R&D activities in China. In 2001, Nokia established a new R&D centre in Hangzhou, a city near Shanghai. They recently announced plans to consolidate their four existing joint ventures there. Motorola has established a new integrated circuit center in Suzhou, in the eastern Jiangsu Province (approx. 95 km from Shanghai) where Microsoft also has its third R&D center in China after Beijing and Shanghai.

6.3. *Performance-oriented motivations*

Customer and market-specific development. One main reason why so many companies are establishing development bases in China is to locally develop products specifically for the China market. The necessity of adapting products to the foreign market is a widely shared belief among many interviewed R&D managers. Selling products without paying attention to the needs of local markets is bound to fail. Locating R&D activities in China allows TNCs to adapt and tailor their products and services to the local cultural and market needs. A typical example is adapting IT user interfaces, telecommunication or car infotainment products to be used with the Chinese language. Moreover, specific local conditions in which products are operating require appropriate modifications and redevelopment. For example, in China some automotive components such as air conditioning and combustion engines need to be redeveloped according to local climatic conditions and local gas quality. In the next 2–3 years, over 75% of growth in electronic manufacturing capacities will take place in China. Risks of such a production shift purely for cost reasons are high; local development and product adaptation in these growing markets can support manufacturing operations and increase competitiveness.

There is an additional benefit to operating in different cultures and countries such as China. A company can develop new products and forge advanced thinking on many product issues. Some managers do believe that products that satisfy the requirements of the most difficult consumer and market environments are likely to succeed anywhere in the world. Microsoft Research Center in China is tackling problems associated with computing in Chinese due to the difficulty in inserting Chinese characters on a Western keyboard. Besides the improvement in software suggestion and error-checking system, researchers also examined data entry methods such as speech and handwriting recognition. The result will make computers more user-friendly in Chinese, but finally will also benefit all computer users (Gelb, 2000).

The elevator and escalator company Schindler established an R&D centre in Shanghai in the late nineties due to its notoriety as one of the most booming and sophisticated markets in the construction business. Chinese customers are less risk averse than western customers, which is typical for booming economies. In 2003 Schindler conducted a field study for a new web-based personalized infotainment system in the elevator cabin – an advanced experiment that would be less likely to be accepted in Europe or the USA. Based on that study Schindler has planned to multiply the system requirements for the product launch worldwide.

Cost advantage. Running similar R&D facilities in China costs about only one tenth of what it would in the USA (Li and Zhong, 2003). The lower wage structure in China attracts TNCs' R&D activities as well. Although the wages of highly qualified Chinese R&D staff is high compared to Chinese domestic level, it is still 1/4 or 1/5 of that of R&D staff salary in the triad regions. Companies in the software industry that moved to India are now starting to evaluate China. The main reason behind this is increased labour cost in India. Moreover, as mentioned in the above section China has enacted a series of preferential policies to encourage establishment of foreign R&D activities which provide further cost advantage potentials for doing R&D in China, such as foreign R&D centres in China that can import certain equipment duty free.

Short R&D cycle time and adaptation to local production processes. Localized R&D allows for a shorter R&D cycle time especially for products that require customer and market-specific accommodations. Furthermore, local R&D activities can assist manufacturing operations to improve quality, learn to produce new offerings, reduce costs, or increase capabilities (Ambrecht, 2002). The packaging specialist, SIG, is going to open an R&D unit in Suzhou in 2003 to support their manufacturing units.

6.4. Business-ecological motivations

Governmental policy. For over a decade, China's increasing sensitivity towards technology's contribution to economic growth has become evident. 'Revitalizing the Nation through Science and Education', a strategy which was officially adopted in 1995 by the Chinese government to speed up Scientific and Technological Progress (OECD, 2002), has led to the rapid growth of China's national science and technology activities. In 2000, China spent $11 billion on R&D, amounting to 1% of its GDP. This represents an increase of 150% over 1995 levels of $4.2 billion (China Statistics Bureau, 2001). Furthermore, although OECD countries provide over 90% of FDI globally, their share of FDI in China is much smaller. Therefore, China has the ability to attract long-term, relatively capital-intensive and high-tech projects from multinational enterprises in OECD countries (OECD, 2003). As a result, China has continued to liberalize the approval process for FDI and a number of preferential policies have been put in place in order to encourage foreign business, especially TNCs, to set up local R&D investments. Chinese policy makers believe that an effective way to bridge the international technology gap is to intensify the linkage with the international R&D community. One important means is the establishment of high-tech parks combined with incentives such as free rent, low tenancy costs, favourable lease terms, and tax relief. As identified by Ambrecht (2002), there are several multi-faceted reasons behind these kinds of policies. Foreign laboratories will bring capital investment, ancillary spending, and job opportunities. Moreover they help to attract excellent ethnic Chinese specialists from around the world back to China to conduct advanced research. The proximity to international research facilities will also spur the Chinese high education system through their demand for local high-quality technical personnel and co-operation with Chinese R&D facilities. Moreover, the business background of these R&D laboratories could help China to create market value from the leading-edge technologies being developed in Chinese universities and research institutions. Furthermore, local R&D activities are considered to be important evidence that a company is interested in developing long-term commitments in China. It helps to build trust and good working relations with the government and to receive official support. However, due to financial incentives and other business advantages, some foreign firms are tempted to register their China activities as 'R&D,' no matter if their research does or does not entail genuine research and development activities (see Walsh, 2003).

Given the pure power of Chinese government, they are in a position to pursue the so-called 'technology for market' policy and play one foreign investor against another in order to accelerate TNCs' investment level and R&D commitment. Prior to China's accession to the WTO, foreign investors were regularly pressurized to transfer technology in return for market access. For example, there was intense competition between several global automobile companies concerning the establishment of an automobile joint venture in Shanghai in the late 1990s, which was speculated to be the last approval of this kind for many years. General Motors finally won the license to establish a joint R&D centre in Shanghai (see *The Economist*, 1999; Walsh, 2003). In this particular case, political pressure from Chinese Government had primarily determined TNC's R&D investment decision.

Continuing economic growth and unique market size. Despite the stagnated world economy, dynamic growth of the Chinese national economy and its overwhelming market size has made China amongst the most strategically important markets for TNCs. Especially in IT and telecommunications fields, multinational giants such as Microsoft, Nokia, Motorola, and Siemens have invested hundreds of millions of dollars into their R&D activities in China, which is in essence an investment in China's future market. For example, China has become the world's largest mobile phone market with more than 200 million users by the end of 2002 (People's Daily, 2002). The critical mass of the Chinese and the Asian markets is increasingly influencing mobile phone size, style and applications globally. As a response to the strong demand for affordable, entry-level mobile phones in the Chinese and Asian markets, Siemens Mobile division established the global headquarters for voice-centric mobile phones in Beijing in October 2002. According to Siemens (2002) this marked the first time that the central responsibility for one of Siemens mobile's business activities had been established in China.

Peer pressure. TNCs' motivations for establishing local R&D in China are rooted in the awareness of possible mid- and long-term competitive advantages that have been discussed in the above sections. Given the increased competition among TNCs in the Chinese market, those who do not have foreign R&D centres have come under increasing pressure to invest in R&D. Even though most interview partners did not want to admit to peer pressure as a driver, it was mentioned during informal follow-ups.

7. Barriers for managing R&D in China

As discussed in the previous section, China is a very attractive location for transnational companies' R&D units. Despite the aforementioned advantages and rewards for setting up R&D activities in China, there are still high managerial barriers that could neutralize the potential advantages. As stated by Perrow (1970), barriers to effective managerial practices are derived from two situational characteristics: complexity and unpredictability. According to the contribution of Smith *et al*. (1996), complexity occurs when problems that managers encounter are multifaceted and methods for dealing with them are diverse. Unpredictability impacts upon the flow of organizational processes and managerial actions and causes uncertainty in managing the company (Smith *et al*., 1996). As we can clearly recognize, most of the identified barriers to managing R&D in China result from both complexity and unpredictability and do not allow attributing them to simply one characteristic. In the following, we have divided the identified barriers of managing R&D in China into two categories: barriers at the intra-organizational level and barriers at the inter-organizational level.

7.1. Barriers at the intra-organizational level

Difficulty in management due to Chinese language and the cultural gap. Given the general lack of experienced indigenous R&D managers in China, the majority of upper R&D management are staffed by foreign expatriates. Unfortunately, most of them do not have adequate or non-management experience in the Chinese environment. The Chinese language is an initial barrier in management. Although some of the top Chinese research staff have a good command of English, most of the local engineers only have limited English capabilities.

An even larger obstacle for Western managers is to overcome the cultural gap during the daily interactions concerning issues like communication style, 'face saving', to name a few. A Western manager may have done everything correctly according to his understanding of good management style. However, lack of experience and sensitivity to Chinese mentality and culture will usually translate to managerial inefficiency, wrong decisions and inadequate leadership. Western managers coming mostly from low context cultures (e.g. Germany, USA) are used to capture the message meaning with words alone. They believe spelling it out clearly is the only way to avoid ambiguity. On the contrary, the Chinese Culture is a very high context culture (Hofstede, 1994). A message is delivered with nonverbal signals (e.g. tone of voice, use of silence, facial cues, and body language), unspoken assumptions, and the context or environment surrounding the conversation. People from high context cultures assume that the receiver of the message is intelligent enough to understand its true connotation. Lack of awareness and proper handling of interference between high and low context communication styles can eventually lead to misunderstanding, confusion and ineffectiveness.

Diversity of R&D staff. The R&D teams of TNCs in China are diversified and are typically composed of three groups of people. Local graduates make up the majority of the R&D staff. Western expatriates and global Chinese comprise the other two groups. Although diversity in R&D teams can increase creativity and innovation, it can also be a source of potential conflict. In addition to general difficulties of managing intercultural teams, one particular challenge lies in the potential differences between local Chinese staff and global Chinese. In our context, 'global Chinese' is a generic term for three subgroups of Chinese people working for foreign R&D: Mainland Chinese returnees with education and working experiences abroad; Chinese from Greater China (i.e. Taiwan, Macao and Hong Kong); and overseas-born ethnic Chinese. On the one hand, they share the same Chinese origin and culture and have almost no language difficulties with each other. On the other hand, due to multilayered differences between these subgroups stemming from such elements as different educational background, different working style and perception, and in particular the huge gap in pay for the various levels (see also De Boer *et al*., 1998); one should be wary to generalize these three sub-groups of Chinese people. Western expatriates are often not aware or underestimate these differences.

Low individual initiative and innovative mindset. The majority of local R&D staff are recruited from China's leading universities. During the interviews, most of the managers shared the opinion that Chinese graduates have a solid education and are highly skilled in solving certain well-defined tasks. But there is an awareness of a lack of practical experience and individual initiative, which is to a degree in line with the findings of Walsh (2003, p. 96). It could be argued that this phenomenon is attributable to the Chinese education system, which is characterized by a narrow curriculum design and very little development of individual initiative. To a greater extent, an R&D staff member's individual initiative is decisive for creativity and innovation. As Walsh (2003) stated, developing a more innovative mindset among Chinese staff is a primary concern of foreign R&D managers at this stage. Risk taking behaviour and entrepreneurship in the widest sense have to be promoted. As a result, management and development of R&D staff in China require much attention.

High employee turnover rates and lack of loyalty. Like other foreign enterprises in China, many R&D departments are plagued by high staff turnover rates, particularly those located in large cities such as Beijing and Shanghai, where sufficient new opportunities are available. In general, there are three main causes of staff turnover. Some leave because they have simply found a better paid job elsewhere, while some go abroad to obtain graduate degrees. Only a few, but worth mentioning, leave to work for or establish high-tech start-up enterprises (Walsh, 2003). This is a common phenomenon that impact not only foreign companies in China, but Chinese domestic high-tech companies and research institutes that are suffering from high turnover as well. Foreign companies are often used as a career springboard. Working for a foreign company provides Chinese graduates not only with higher salary and practical experience; it also makes them familiar with Western management practices and provides them with possibilities of advanced on-the-job training. References from these jobs will help them get jobs with better pay and possibilities. The worst case scenario is that they can use this experience to get hired by competitors.

As stated by several foreign managers and also confirmed by Chinese employees, compensation strongly influences the affiliation and loyalty of Chinese R&D staff. Beside money issues, one should not ignore the level of attachment to Western employers. It could be argued that given the fact that China has made a strong effort in building national consciousness, many Chinese employees strongly associate themselves to their own country rather than to their Western employer. As a result, some R&D managers have expressed a reduced trust in local people, since they are afraid that this lack of loyalty will lead to a brain drain to competitors. This is especially relevant within Sino-foreign joint ventures where the parent company of the Chinese partner or simply the partner themselves participates in or owns other domestic enterprises operating on similar business fields. For example, ABB, a Swiss power and automation technologies giant, has lost plenty of technological knowledge through their Swiss-Chinese joint ventures. The lack of trust in local people is one reason why Schindler's competitive intelligence unit in Switzerland consists of only two Chinese staff members.

Building long-term staff loyalty is a challenge for human resource managers in China. It is particularly relevant for R&D labs, given that know-how travels with people.

Remaining governmental influence within the company. It is worth mentioning the governmental influence within a company is a further management barrier in China. Even if the intervention on foreign enterprises' activities by the Communist Party of China (CPC) has decreased in recent years and the party branch (i.e. the party secretary) within some wholly owned foreign companies is not involved in the business at all, some interviewees still mentioned the strong governmental influence. As one manager said: 'There are still numerous possibilities for Chinese government to make everything difficult'.

7.2. Barriers at the inter-organizational level

Bureaucracy. As mentioned in the above section, the Chinese government provides incentives for foreign R&D activities in China. According to the experiences of some interviewed R&D managers, receiving promised preferential conditions such as tax relief and other incentives can be a stressful and prolonged procedure, due to multiple bureaucratic hurdles and very specific rules. Importing test materials can be difficult (IBM), transferring people from Beijing to Shanghai requires an official permit (requires long-term preparation – Siemens, ABB).

Therefore, a good relationship (GuanXi) network with the government is crucial to business efficiency and success. This kind of relationship network needs time and occasional financial support. As one Western expatriate manager mentioned, relationship investments take the form of sponsoring of IT equipment for local universities or other contributions to non-profit official organizations such as a municipal kindergarten. However, one should not mistake this kind of financial aid for a bribe.

Uncertainty in legal changes. Due to lack of transparency in Chinese policymaking, China's industrial, political, legal, technological policies and strategies are difficult to discern. This provides more uncertainty for foreign R&D activities in China. For instance, in the Automobile industry, China sees Europe as a role model with regards to industry norms and regulations. As a result, the Chinese Government ambitiously follows the European automotive norms (e.g., emission norms (EURO III, IV), airbag obligation, tire pressure control, brake power control). The validity of such norms for automotive products will be left up to the government's discretion. This kind of unpredictability will make conducting R&D very challenging.

7.3. Uncertainty in fairness of R&D cooperation

As was often mentioned by interviewed mangers, there are uncertainties concerning the fairness of R&D cooperation due to insufficient legislation (especially intellectual property rights) and a strong protectionism of regional governments. Most of the potential cooperation partners are state owned enterprises (SOEs) and spin-offs of former SOEs. Unwanted and non-transparent knowledge/technology transfer could be carried out within this network, something that is not obvious to an outsider. Even if the foreign partner has clear evidence of this kind of unwanted technology transfer, their means of counteracting it is limited. Since local governments are in most instances an important stakeholder, legal proceedings are not the best way to solve these kinds of problems. It could even hinder the company's future operations.

Intellectual Property Rights. Given the challenging nature of the Chinese economy, foreign investors must assume some inadvertent technology transfers. As Schumpeter noted, innovations should lead to temporary monopolistic profits in order to harvest previous R&D investments. Therefore a strict legal intellectual property system with little uncertainty for the innovator is a prerequisite for technological process and high rates of innovation. The current Chinese intellectual property rights (IPR) framework has been in existence for less than two decades (Yang, 2003). China has made progress in protecting IPR and has ratified different international treaties and conventions to show the world that it strives to be in step with international IP standards, yet piracy of intellectual property (IP) remains rampant in China. This is an area in which foreign enterprises have serious concerns. The International Intellectual Property Alliance estimates that over 90% of business computer software in China is pirated (IIPA, 2003). Microsoft loses several billion dollars due to piracy each year. One major reason for this kind of concern is weak IP infringement enforcement at the international level. Starting and winning a patent case in China is still almost impossible and definitely time consuming. Additional concerns of foreign compa-

nies regarding IPR include a long patent application procedures and a lack of public acceptance of IPR legislation (OECD, 2003). Sometimes, the lack of IP protection stops foreign firms from importing their core technologies, research, or equipment to China. Nevertheless, the number of foreign applications for patents attributable to high tech industries has continued to rise. This is mainly due to increased competition and a governmental policy that transfers technology to China.

IP management in China is intricate but achievable if enough effort and resources have been put into it. For example, Siemens' corporate research lab in Beijing has a special group dedicated to intellectual property issues in China. New technologies stemming from wholly foreign-owned R&D centres in China are filed initially, and in some cases exclusively, in the foreign companies' home country. In general, foreign investors are encountering difficulties in IP when conducting innovative research in China at present and as a result truly innovative results in China will continue to take time.

8. Managerial implications

In our interviews, the human resource challenge was strongly emphasized. Local R&D staff are inexpensive and qualified in China. Yet due to the cultural gap and language problems, huge potential remains untapped. As previously outlined, foreign R&D activities are mainly set up because of input or performance oriented potentials. From a competence based view this can be described by the absorptive capacity (see Levinthal and Cohen, 1990) and multiplicative capacity of the R&D unit. Both capacities determine a firm's capability to link its peripheral units to the external environment. A higher absorptive capacity results in a better knowledge sourcing capability from the local community, while a higher multiplicative capacity improves the firm's capability to efficiently link the output of the peripheral unit to global TNC's operations (R&D effectiveness and efficiency, technology transfer). In order to fulfil the two basic functions of an R&D unit, to absorb local skills and knowledge and to multiply the output to the TNC's operations; human linkages are required. We identified two major sources to develop linkages for foreign R&D in China: expatriates and global Chinese (see Figure 1).

Expatriates build up the R&D unit, establish the management system and corporate processes as well as develop the linkages to the corporate operations, (i.e. corporate R&D, local sourcing, corporate marketing and regional product management). Concerning the issue of the cultural gap, a comprehensive training program enables expatriates to understand the Chinese environment, to develop awareness of cultural differences, and to facilitate their intercultural communication skills. Many proven Western management styles might not succeed in China due to cultural differences. As Walsh (2003)

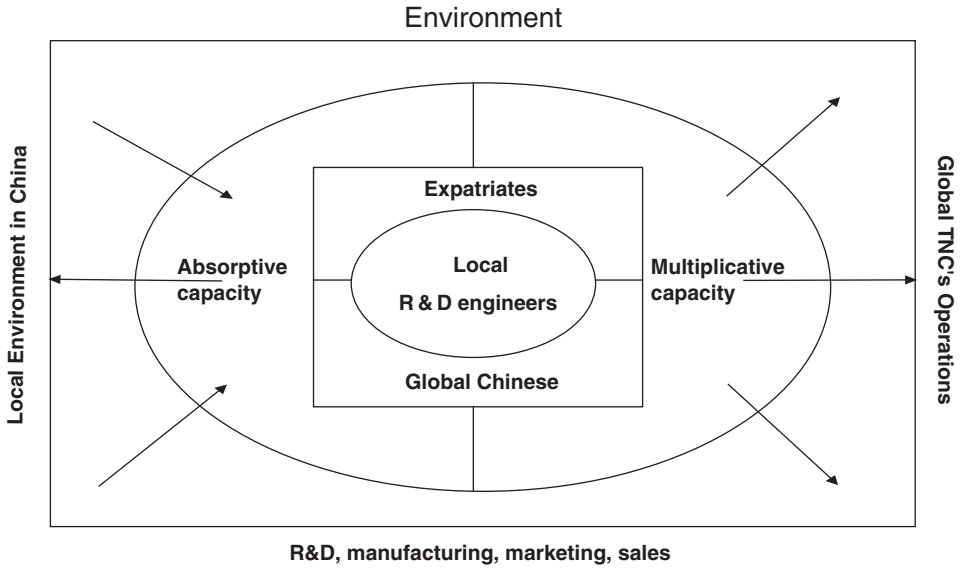

Figure 1. Expatriates and global Chinese increase the absorptive and multiplicative capacity of foreign local R&D units in China.

stated, many Western managers intend to change Chinese work habits and attitudes to more closely conform to Western business models and styles, while Chinese staff seem keen to learn these methods and to change their performance accordingly. Yet the strong influence of Chinese culture and mentality still affect their way of thinking and approach to innovation. To be successful, foreign managers will have to identify and adapt these challenges to their advantage. One of the major drawbacks of using expatriates is the high cost. At Schindler, the costs of an expatriate R&D manager can be five times higher than in Switzerland (due to personal services, adequate housing, international schools for expatriates' children, memberships in several clubs, accommodation, car etc.). On the other hand, after four years experience, Schindler had positive experiences with global Chinese who had spent a certain amount of time in workplaces abroad. They are efficient levers and can be also built up by systematic job rotations (e.g., by Siemens, IBM) Absorptive and multiplicative capacity will increase by using these human bridges. US based TNCs in particular can take advantage of global Chinese, due to the huge overseas Chinese community in the USA. It is not difficult to find global Chinese who have overseas education and can speak Chinese. However, the overall requirements on these global Chinese, ones who can really serve as mediator and leverage absorptive capability, are in the reality much higher than some HR managers expect. The following issues are often underestimated and need to given more attention.

First, it is obvious that a 'human bridge' needs to have the required technical expertise and knowledge in a specific field. Additionally, he/she also needs to be able to communicate with Chinese researchers and staff about these issues in Chinese. Since most of the global Chinese have overseas education and have spent many years abroad, some often have lack the ability to translate specific terms into Chinese.

Second, the 'human bridge' should be able to withstand high pressures from both sides, from both their Western employer and Chinese staff and colleagues. Their Chinese colleagues will have noticeably higher expectations. The big gap in salary is often reason. Third, the human bridges need to be sensitive towards both Western and Chinese cultures and need be able to handle intercultural conflicts. Although the global Chinese come from a Chinese culture, it does not necessarily mean that they have the required sensitivities and skills to meet intercultural challenges and solve these kinds of problems.

These issues are frequently underestimated when filling these kinds of positions. As a result, without any customization and preparation to the 'old-new environment', the global Chinese may have difficulty in satisfying their appointed tasks as 'leverager' and 'mediator' in China. Their impact will be called into question. Therefore, we do believe proper training and preparation is also necessary for the global Chinese as 'human bridges' and leverage absorptive capacity especially regarding soft skills. China should be a mandatory stop during their preparation and job rotation. It was also found that strategic cooperations with reputable universities and official research institutes can help TNCs' R&D activities in different aspects: First, Chinese universities and research institutes are sources of top-class local talents. Second, they do have important and advanced facilities that could reduce R&D investment through partnering. Third, since most of the universities and research institutes have close connections with government or Chinese ministries, joining up with them could mean access to the important official 'GuanXi' and competitive benefits such as less bureaucracy and access to information concerning official lines of policy. Uncontrolled technology transfer may be the cost for having these competitive positions in certain partnerships.

As mentioned in the previous section, R&D cooperation could contain uncertainties especially regarding unwanted knowledge and technology transfer through a cooperation partner. Therefore, the choice of an R&D cooperation partner should be carried out with more caution. Additional attention should be paid to the complex network of relations behind the cooperation partner and its relation to other competitors in order to prevent unwanted and non-transparent knowledge/technology transfer.

Other managerial recommendations from the interviews include: A consistent management information system which is as global as possible and as local as necessary, in order to help increase the capacity of the R&D unit. This includes a global standardized stage-gate-process to enable transnational R&D, but also local freedom in the creative early innovation phases. A politically sensitive 'match maker' who knows the political rules and open doors could further increase the absorptive capacity. One possible scenario has the party secretary of the company serving as a mediator between foreign investors and the government.

9. Conclusion

The emergence of foreign R&D activity in China is a recent phenomenon and has rapidly increased since the mid-nineties. This trend will carry on into the future. With this contribution, the authors hope they have added to the understanding of the drivers and barriers of foreign R&D activities in China. Input- and output-oriented, and business-ecological motivations predominantly provide reasoning for TNCs' R&D endeavours in China. The Chinese government has made many attempts to accelerate foreign R&D investment in China through available political means. Nevertheless, based on the interviews and talks conducted during the research, the authors do believe that the political pressure does not decisively influence the R&D investment behaviour of TNCs. Accompanied with China's WTO accession; the country has successively increased its integration into the global economy. Since this is becoming a continued trend, input- and output oriented motivations will, especially in the medium and long term, outweigh the driving factors of foreign R&D investment in China. The more there are advantages created by local R&D activities in China, the greater the challenges of managing on-site R&D will be for TNCs. The major barriers such as complexity in human resource management, bureaucracy, uncertainty in legal changes and low confidence in the protection of intellectual property rights will also last for at least the medium term. We believe that the success of foreign R&D endeavours in China depends strongly on a realistic estimation of its advantages, and on the awareness and the proper handling of identified barriers. TNCs intending to establish R&D sites in China should cautiously set local R&D activities in accordance with their internal strategy of R&D internationalization and more importantly with their long term purpose in the country. Future research in the field of foreign R&D activities in China may emphasize the evaluation of best practice of overcoming obstacles in managing foreign R&D in China.

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