International R&D Strategies in Companies from Developing Countries – the Case of China

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Abstract

Traditionally, international R&D is a phenomenon of firms originating from advanced countries such as North America, Europe, and Japan. Based on the analysis of 1269 R&D locations, a new research framework is proposed that accounts for the increasing share of R&D toward or from developing countries. Investigating technology-intensive Chinese firms, motivations, strategies, and barriers to R&D internationalization are analyzed. The paper proposes two concepts of international R&D: "innovation capability enhancing" and "innovation capability exploiting", respectively, denoting superimposed networks that allow the absorption and implementation of new technologies.

1. Introduction

International R&D is a by-product of intensified merger and acquisition activity (Gerpott, 1995) and more deliberate internationalization of corporate innovation (e.g., Bartlett and Ghoshal, 1989). Research on the latter has informed us about different typologies of corporate technology activities (e.g., Medcof, 1997), R&D internationalization strategies (see, e.g., a special issue in *Research Policy* in 1999), R&D location decision-making (e.g., Voelker and Stead, 1999), multi-site R&D project management and technology transfer (e.g., Chiesa, 2000), and intra-organizational technical communication (Katz and Allen, 1984). Most of this research — with few exceptions — focused on R&D conducted in advanced developed countries (as the term is used by UNCTAD and other international organizations, henceforth 'advanced' countries), partly because these countries were responsible for the bulk of global R&D conducted, partly because their protagonists were more easily accessible and forthcoming, and partly because R&D in non-developed countries (henceforth, 'developing' countries) was insignificant in scale. For instance, a review by von Zedtwitz and Gassmann (2002) indicates that, on average, European firms conduct around 30% of their R&D abroad (half of which in other European countries), American firms about 8-12% overseas, and Japanese firms no more than 5% outside their home country. Data, and research, on R&D in developing countries is scattered and few. Only a handful of countries outside the advanced economies receive some research attention, among them are Singapore, South Korea, India, and, most recently, P.R. China.

The principal research purpose is to illuminate R&D internationalization by firms in developing countries, with a focus on China. First, we asses the extent of international R&D emerging from developing countries, proposing a 2x2 model of past research on international R&D. Based on research conducted on Chinese technology-intensive companies, strategies and struggles of R&D internationalization are investigated and analyzed. Due to their transitionary position between underdeveloped and advanced countries, the data seems to suggest that firms from a developing country organize their international R&D activities as both capability-enhancing or capability-exploiting structures. The paper concludes with open research areas and some preliminary implications for research, management, and policy making.

2. Research Framework and Directions

R&D has always been considered a domain of firms in technologically advanced and economically developed countries. Indeed, the ten largest countries in terms of GDP also lead in terms of technology-intensity (except for P.R. China and Brazil). Transnational companies account for substantial shares (between 33% to 57%, according to a mid-1990s study reported in Gassmann and von Zedtwitz, 1999) of their total national R&D expenditures. Multinationals dominate private international R&D investments; of the 100 largest MNCs in the world (in the year 2000), 94 were headquartered in advanced countries, 3 in China, and

one each in Mexico, Venezuela, and South Korea. Patent applications in the most important markets are led in numbers by large multinationals from the US, Japan, and Western Europe. Clearly, there is a dominance of domestic and international R&D by firms in advanced countries (Dunning, 1988; UNCTAD, 1999, 2001).

R&D in developing countries has figured less prominently. Most research has concentrated on technology transfer to these countries, and their capacity to absorb advanced technologies from abroad (e.g., Kim, 1980, 1997; Lall, 1990). Without a doubt, the level of science, technology, and innovation has been increasing over the last years, but the investment ratios of S&T to GDP are still far behind advanced countries (see Schaaper, 2004; OECD, 2002). Moreover, the leading multinationals from developing countries tend to be low on technology-intensity, and harvest natural resources such as real estate, oil & exploration, and mining & materials. R&D by the few technology firms in these countries tends to be comparatively weak: Lack of S&T resources and lack of local market demand for sophisticated and expensive technology goods discourage private efforts in serious R&D.

For the first time since the mid-1980s, when international R&D became a more widespread practice among technology multinationals, we are witnessing the emergence of a new class of high-tech companies from developing countries, most notably India and China. These companies compete in highly technology-intensive industries, in which customers demand great rates of innovation, and in which timely application of technical know-how is paramount. They have one thing in common: they are headquartered in large developing economies. They differ from their predecessors in South Korea and Japan in that they are facing international competition in their home markets, that technological change has accelerated since the 1970s, and that know-how — and the workforce — has become more mobile. In other words, the environment has become more global.

Competition among these companies can be extremely intense, which does not favor the internationalization into foreign markets. However, there a few companies have emerged that pursue R&D of international caliber nevertheless, such as Embraer in Brazil (the world-wide third largest supplier of mid-range aircraft), Huawei (a leading telecommunications firm from China), and Infosys (an global IT services provider in India). The evolution of companies from developing countries, and the development of their innovative capacity has been the subject of recent investigations (see, e.g., Lee et al., 1988; Bell and Pavitt, 1993; Sung and Hong, 1999; Xie and Wu, 2003; Xie and White, 2004). However, the extent to which firms from developing countries develop international innovation capacities and build global R&D networks has not been studied in detail yet. Here too the best explanation is probably the very limited number of firms from developing countries to undertake such international R&D, at least until recently.

Figure 1 summarizes some of the previous research trajectories in international R&D research. The first type concerns "traditional" R&D internationalization among advanced countries, i.e. mostly within the triad countries of North America, Western Europe, and Japan. This area of R&D internationalization has been widely researched, and yielded a very valuable and rich literature as well as an fundamental albeit initial understanding of transnational innovation management. Most of the international R&D flows are covered by Type 1 research, as indicated by the preferred routes of foreign direct investment (the Triad countries accounted for 71% of all FDI inflows and 82% of all FDI outflows in 2001). However, the rise of China (and to some extend India) as a principal recipient and source of FDI in 2002 and 2003 has led to a new, "modern" category of research, denoted Type 2 in Figure 1. Examples of Type 2 R&D internationalization is IBM's establishment of R&D in India, Microsoft's Research lab in China, and Fujitsu's Development Center in Malaysia. This modern form of R&D internationalization became popular in the late 1990s, driven in part by improved economic conditions in South-East Asia, China, and Eastern Europe, in part by strategic considerations of parent companies to set global standards and build global brands, and in part by a growing understanding and financial commitment of MNCs to support local sales with local R&D efforts.

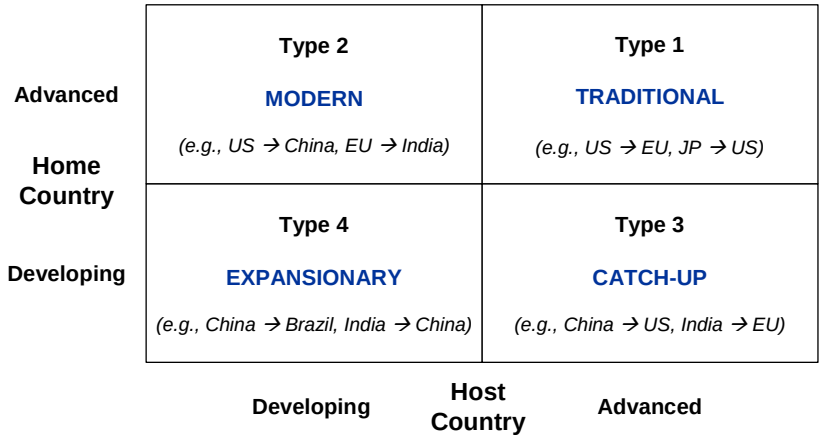

Figure 1. Four phases or types of research on R&D internationalization.

Type 3 and 4 in Figure 1 denote a novel, so far mostly ignored direction of R&D internationalization. Arguably, researchers such as Lall (1987, 1990) and Kim (1980, 1997) have studied the acquisition and development of technological competencies in developing countries, but the notion of firms headquartered in developing countries establishing R&D capabilities outside their home countries is new. The espoused view was that firms in developing countries were too busy absorbing technology transferred from abroad, and hardly capable to push technological boundaries themselves. They would use their new competitive advantages to defend and build domestic market shares, and if they were sufficiently attractive enough, they would be acquired by much larger foreign multinationals. Some countries imposed policies protecting domestic technology companies, either by making foreign acquisitions more difficult or by curbing competition from MNC subsidiaries. In any case, the internationalization of business and technology has largely been unidirectional from advanced to developing countries.

Type 3 hence describes firms from a developing country conducting R&D in an advanced country. Because of their principal motivation of "catching up with advanced countries," this type of R&D internationalization is labeled "catch-up," with representatives such as Samsung of Korea investing in R&D in Europe, and Acer of Taiwan in the US. These firms are naturally attracted to using advanced countries as R&D bases, partly in order to acquire local technology and science, partly in order to support local product

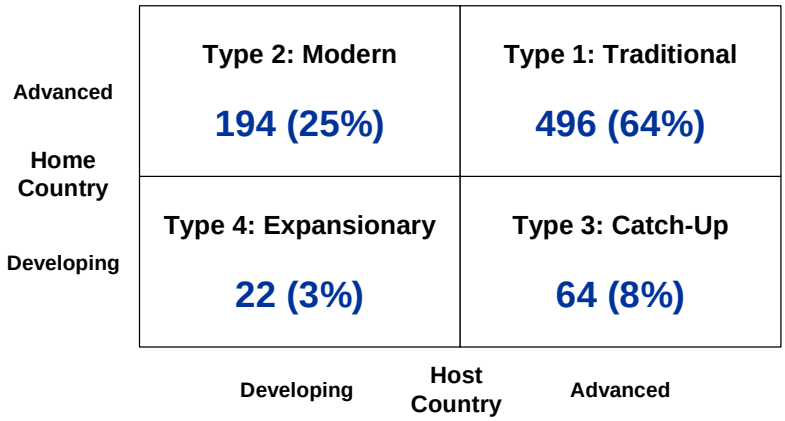

Figure 2. Absolute and relative number of 776 international R&D units and their classification to Types 1 – 4. Classification of countries into 'advanced' and 'developing' followed definitions used by international organizations such as UNCTAD an others.

development.

Type 4 R&D internationalization is when a firm in one developing country invests in R&D in another developing country. The reasons for this kind of investment may be in supporting second generation technology transfer (when the earlier recipient of a technology transfers a technology on to a even less developed country), or to support other, local business activities. An example is Acer's R&D lab in China, and Huawei's R&D center in Bangalore, India.

As can be seen in Figure 2, the instances of Type 3 and 4 internationalization are not trivial. Using a database comprising of the locations of 1269 R&D units, 776 locations were identified as 'international', meaning that the parent company was headquartered in another country. 64 belonged to Type 3 or the Catch-up Type, while a respectable 22 belonged into Type 4 or the Expansionary Type (496 R&D units belonged to Type 1 or the Traditional Type, and 194 to Type 2 or the Modern Type of R&D internationalization.) At least in this database, international R&D from developing countries already constitute about 11% of all international R&D.

These Types 3 and 4 of R&D internationalization are not well understood and—to some extent—even contradict established views on international R&D. For instance, firms from advanced countries invest in R&D in developing countries in order to exploit labor and operating costs advantages; hence under what circumstances would a company from a developing firm consider giving up this particular advantage by going into a country with a highly adverse purchasing power parity? Or, as long as companies from developing countries are still struggling with the incorporation of mature technologies transferred by joint venture partners, how can they assume that they are ready to absorb far more sophisticated technology currently under development in advanced countries? Furthermore, these foreign advanced technologies are probably without differentiation potential for firms from developing countries in the more important domestic markets.

With its high GDP growth rate and rapid industrialization of the coastal areas, as well as a growing number of technology-based companies, China provides a very fitting example of a developing country. China also faces many of the same problems other developing countries need to confront, such as a high degree of state control, low purchasing power of its domestic currency, comparatively low rates of tertiary education, and a lag in developing an economic and legal framework conducive for private business. More specifically, the research presented in this paper pursued the following research questions:

- How significant a role play companies from developing countries, in particular China, in worldwide R&D? How relevant is this topic for future research?
- What motivates companies from China to conduct R&D elsewhere? What are push, what are pull factors?
- What strategies do Chinese firms employ in order to expand R&D internationally?
- What barriers and challenges do Chinese companies face in doing so that may be more specific to them as being from a developing county?

3. Research Methodology

The aim of this research was to investigate a well researched phenomenon (internationalization of R&D) in a new environment (China). With this objective, an empirical, quantitative research approach would have been appropriate. However, initial exploratory interviews indicated a low intensity of international R&D in Chinese companies as well as a high disinclination to cooperate in academic research on R&D management. In one of the closest comparables to the present research, Jin Chen of Zhejiang University attempted to study international innovation by Chinese companies but received only 28 valid questionnaires out of 279 sent out (Chen, 2003). With response rates this low, and the main focus of the research questions to be qualitative in nature, it was concluded that survey-based research would be ineffective in gathering the information necessary for purely quantitative empirical analysis. Instead, it seemed more fruitful to focus on the top Chinese companies and conduct in-depth research.

Data for this research was thus collected mostly by personal research interviews, and complemented by database research. Research interviews focused on senior R&D managers in selected Chinese companies,

most of which are leading firms in their industry (Lenovo, Huawei, Haier, Kelon, Founder, ZTE, Longshine, China National Petroleum, Datang, Dongfeng, NetEase). Only the first six of these companies operate international R&D units, while the last five did not posses foreign R&D presence as of the end of 2004. Both groups, however, were investigated as the research objective also included to identify barriers and challenges of R&D internationalization. Most of the interviews were conducted in late 2003 and 2004. Database and internet research was conducted by researchers familiar with the Chinese language, thus including the much richer documentation available in Chinese. Research reports were sent back to the interview partners and feedback was requested to correct erroneous interpretations, to ensure greater validity of the data. In each case multiple sources of information were used to increase reliability of observations. Although only representing a small selection of Chinese companies, the collected R&D data was compared to an international database of R&D locations and investment hosted by the Research Center for Global R&D Management at Tsinghua University in Beijing.

4. What is the significance of Chinese R&D internationalization?

Most of Chinese companies are relatively young (and therefore comparatively small) and focused on domestic markets. A World Bank survey of 1500 high-tech companies in China found that they averaged only about 600 employees and were between 10-15 years old. Even well-known Chinese companies tend to be small: Lenovo, China's largest PC manufacturer, has a turnover of only 4% of IBM's (at least before its acquisition of IBM's PC business in late 2004), and Haier, China's most famous brand (according to a 2003 survey) had sales of US$9.7bn in 2003. Furthermore, 50% of the Chinese firms' supply network is located within their cities, and 75% within China, as Ed Steinfeld (2002) notes in his analysis of the World Bank 2001 report. Much of the R&D spent seems to be directed towards technological learning (e.g., Kim, 1997), but little of it results in truly innovative products. Rather than building dominance in a particular industry through technological progress, Chinese companies tend to diversify into other sectors in order to exploit scale economies. As Steinfeld (2002) notes, Chinese "firms focus on activities with low barriers to entry. Once the cost pressures become too intense, rather than moving upward into higher end activities or taking the time to develop proprietary skills, the firms diversify into other low entry barrier markets. The products themselves … are standardized." As a result, most of Chinese R&D is opportunistic and hardly standard-setting.

Given these rather sobering interpretations of the quality of Chinese R&D, what is the scale of international R&D by Chinese companies? Unfortunately, no representative data exists for China, but a comparable can perhaps be computed using data from other developing countries. Earlier research indicated

Figure 3. International dispersion of leading Chinese R&D-intensive companies (N=77).

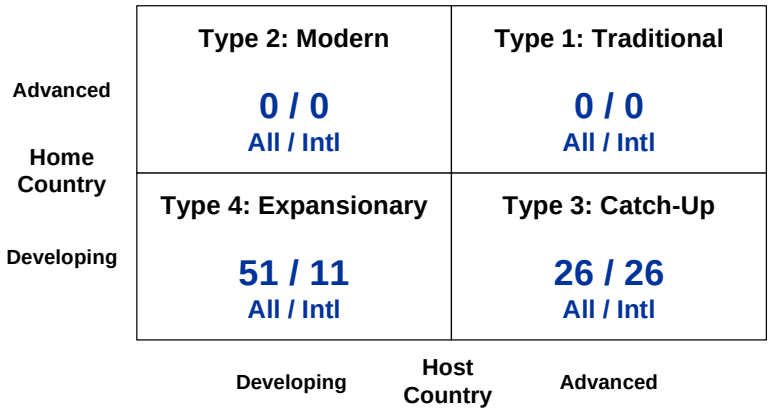

Figure 4. International R&D of Chinese companies toward advanced and other developing countries.

that at least in advanced countries, up to 70% of international R&D was conducted by the top-150 global companies. In an attempt to approximate the volume of international R&D conducted, the author took the fifty largest MNCs from developing countries, eliminated non-technology companies (33 remained), summed up their weighted foreign sales (as reported in WIR, 2001), and assumed an average of 2% R&D intensity per firm. Given an average lag of approximately 50% of R&D internationalization behind foreign sales (estimated on the basis of von Zedtwitz and Gassmann, 2002), this results in a total overseas investment in R&D of about US$500mn annually for the leading firms from developing countries. This is equivalent to the R&D budget of a single reasonably-sized technology-intensive MNC and hence hardly impressive given the scope of this research.

The Chinese firms in the studied sample operated 77 R&D units, 40 in China and a surprisingly high number of 37 abroad (see Figure 3). However, most of these R&D units are quite small in size, with a few exceptions such as Huawei's software lab in Bangalore (550 engineers in 2003 and expected to grow to more than 2000 by 2005). Haier alone operated ten small-scale research units abroad, which focused on technology monitoring and other non-indigenous research activities. The 26 R&D units in advanced countries were predominantly located in the US (11) and Europe (11), and mostly serving as listening post or in product design roles. Japan with only 2 Chinese R&D units seems to be somewhat underrepresented in this sample, probably due to the small sample size. However, even in the complete database of 776 international R&D units, Japan only accounts for 55 or approximately 7% of total foreign R&D labs.

11 of those 37 foreign R&D units (just under one third) are located in developing countries themselves, thus falling into Type 4 labs (see Figure 4). Chinese firms thus account for about half of all international R&D sites owned by another developing nation. Some of these R&D units are extremely small (e.g., there are literally just a handful of people in Pakistan and Iran), but India has attracted quite substantial Chinese R&D investment.

In conclusion of this descriptive chapter, even if only physical internationalization of Chinese R&D is considered (ignoring, for the moment, funding of research at non-Chinese universities and participation in international research programs), China's R&D globalization has already reached a level comparable to some smaller but more advanced European countries.

4. Determinants of R&D Internationalization of Chinese Companies

4.1 Motivation and Objectives

"Every multinational will set up in China. Margins are low here. If we don't go outside, we cannot survive" (Haier's CEO Ruimin Zhang, quoted in The Economist, 2004). Haier, with three industrial parks in the US, Jordan, and Pakistan, ten listening posts in Seoul, Sydney, Tokyo, Montreal, Los Angeles, the Silicon Valley,

Amsterdam, Vienna, Taiwan and Hong Kong, and design centers in Lyon, Los Angeles, Tokyo Amsterdam, and four other cities, is well on its course towards R&D internationalization. The latest addition to their R&D network is a design center in India, opened in late 2004.

What drives Chinese companies to set up R&D overseas? Given the fact that China itself is a huge and still growing market, most market-oriented R&D is likely to be retained and developed at home. Given also that China still receives a great amount of foreign technology (see e.g. Jolly (2004) for the results of a survey of the motivations of Sino-Chinese joint ventures), we can hypothesize that Chinese firms internationalize R&D in order to develop alternate channels of technology sourcing from advanced countries (hence, mostly home-base augmenting sites in Kuemmerle's (1997) notation). Automobile manufacturer Dongfeng Motors has established four listening posts in the US, Germany, the UK, and France for the purpose of being close to major competitors (not markets) and their technological bases. Note that Dongfeng recently reorganized itself to become a major 50-50 joint venture company wit Nissan Motors of Japan. The new Dongfeng-Nissan R&D center in Guangzhou has an investment of US$40mn and serves as a platform to combine Japanese automotive technology with Chinese standards and product requirements.

Efficiency-driven rationales (see Gassmann and von Zedtwitz (1999) for an overview) such as the exploitation of multiple time zones, critical mass of R&D, and local cost advantages, hardly play a role for Chinese companies abroad. As a matter of fact, many foreign companies come to China because of cost advantages, hence Chinese R&D abroad tends to be more expensive than at home, and hence less likely to be set up in the first place. However, in cases where Chinese firms operate large manufacturing sites abroad, local R&D has been seen to emerge in support of product localization and process innovation (e.g., Haier's R&D site collocated with its Camden plant in South Carolina, USA).

While input-related rationales are probably the strongest reasons for Chinese R&D internationalization in advanced countries, market and output-related determinants may explain the establishment of R&D in other developing countries such as Iran, Jordan and Chile. Haier's prides itself for customer sensitivity; for instance, it developed air conditioners to cope with particular adverse desert conditions in the Middle East, and designed washing machines such that they could also handle cleaning vegetables in rural Asia. ZTE's R&S sites in Chile and Pakistan are dedicated to local product adaptation, thus support local business development. However, the emergence of R&D in other developing countries is still in its infancy.

Political, regulatory and governmental factors were not mentioned as having a strong impact on the decision where to set up international R&D sites. However, as more and more Chinese companies develop indigenous intellectual property, foreign companies and states are attacking Chinese companies abroad over their earlier IPR infringements at home. As a result, Chinese companies are barred entry into foreign markets based technologies that they use domestically. Local R&D centers could overcome these difficulties by developing local technology which, in the process, would build new technological competencies for Chinese firms abroad.

International R&D is often also a consequence of merger and acquisitions. Although Chinese companies have been more of a target than a source of M&A, this seems to be changing, as show the investments of Shanghai GM in GM Daewoo and the acquisition of Germany's Schneider by TCL. Thus, R&D units of acquired companies become part of the Chinese firm's R&D network, often making international coordination necessary.

4.2 Evolution of R&D

The past two decades produced a number of descriptions of strategies for internationalization of R&D and innovation. Based on Perlmutter's (1969) and Bartlett and Ghoshal (1989) model of internationalization of organization, Gassmann and von Zedtwitz (1999) developed an evolutionary model of international R&D organization, which fits our purpose of studying the early stages of international Chinese R&D. They describe five types of international R&D organizations: ethnocentric centralized R&D (with a dominant R&D center serving far-away markets), geocentric centralized R&D (where the R&D center engages in cooperative projects with customers and other research institutes), the R&D hub (with the R&D center serving as the central information and decision-making platform for all global R&D units), polycentric decentralized R&D (of R&D units with little global alignment and coordination), and the integrated R&D

network (in which all R&D units are equal partners and information and decision-making is freely shared).

Companies without international R&D units have either ethno- or geocentric centralized R&D organizations. In the research sample, this is the case for Lenovo, Netease, CNPC and Longshine. Netease, an Internet service company with almost 200 million registered accounts, actually shifted its development center from San Francisco, CA, where it was originally founded, to Beijing and Guangzhou, as the company relocated to China. Most of the technology is imported from the US and more advanced IT companies, but a large engineering staff writes code and programs targeted at the Chinese market. Some of its engineers are foreigners who prepare Netease for more global innovation challenges. Other companies have engaged in a number of cooperative projects and alliances, for instance Lenovo with Intel and Microsoft, and CNPC with Shell and ExxonMobile. They are becoming more 'open', and hence overcome ethnocentrism for the benefit of a more geocentric outlook (see Figure 5).

Moving towards greater physical international R&D presence are companies like Datang, Founder, Kelon, and Dongfeng. Datang had some less successful experience of joint ventures with foreign companies such as Lucent of the US, but have now formed JVs with Philips, Samsung, and UTStarcom. It seems on track with R&D internationalization as it explores greater use of its Iranian R&D site. Its CEO has a PhD from a Belgian university and work experience in a Siemens R&D lab. Founder recently set up an R&D lab in Scotland, which it plans to expand into its new European headquarters. Dongfeng's alliance with Nissan has obvious consequences of internationalization of product development between China and Japan at the least.

Some companies have firmly established global R&D networks, such as ZTE, Huawei, 3NOD, and Haier. ZTE established its first three foreign R&D centers in the US and Chile in 1998, and founded more R&D labs in Korea and Sweden since. Huawei also has solid international R&D experience. It was the first Chinese company to set up an R&D center in Bangalore in 2000, earmarking over US$100mn for the Indian R&D site, which it expects to serve the Indian subcontinent, the Middle East, and Africa as strategic markets. At 550 engineers in 2003, it is expected to grow to a staff of 2000 by 2005. 85% of the R&D staff are Indian nationals, as the purpose is the tap into the rich Indian expertise in software design, 3G mobile communications, wireless infrastructure, network management, etc. Huawei also operates JVs with Siemens, 3C, Qualcomm and Microsoft to position itself favorably in the upcoming next-generation mobile communication technology. Almost 46% of its employees are in R&D, although due to the lower labor costs in China, the overall R&D to sales ratio of 10% is more in line with industry averages.

4.3 Barriers and Problems

What are some of the greatest barriers and problems of Chinese companies to expand R&D internationally? In part, they are reflected in typical internationalization problems of companies from developing countries, but some are more specific to China, and some are specific to R&D. Steinfeld (2002) found three principal

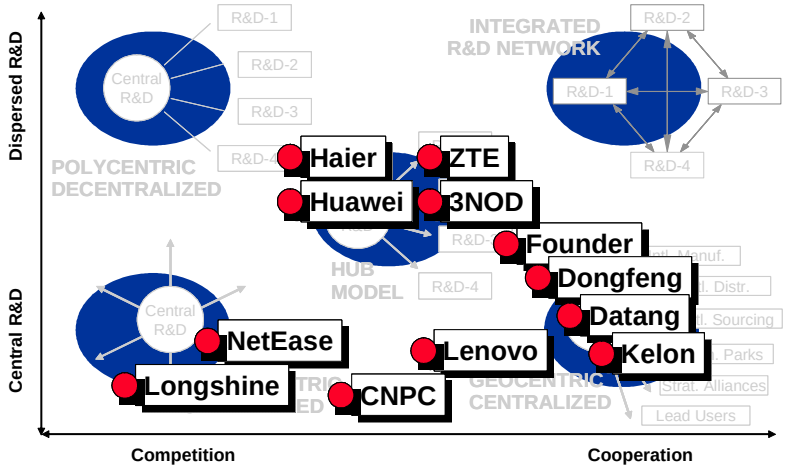

Figure 5. Evolution of Chinese companies towards greater R&D internationalization.

challenges of Chinese companies to internationalize:

1. Chinese companies have a size disadvantage: due to its inferior size, they cannot compete head-to-head with much larger multinationals
2. Chinese companies continue to emphasize local business integration despite increasing international sales. For instance, supply chains are still highly local or regional, and there is little integration with global technology suppliers. As a consequence, Chinese companies are often barred from more value-added activities, and focus on low-cost competition, and hence unable to engage in product differentiation as a source of competitive advantage.
3. The also lack sufficient product innovation required to charge higher profit margins, rather than just cost reduction through efficiency innovation. While this produces advantages for manufacturing and customers, it also locks in Chinese companies in mostly domestic-oriented innovation.

Additionally, the sampled companies a number of drawbacks relating to lack of resources, lack of experience, and entry barriers in new markets:

Lack of cash and resources: Although China is an expanding market, profit margins are low and hence only little can be reinvested in R&D. Investment in groundbreaking R&D (as opposed to technology adaptation and product localization) is more costly, and the first movers are likely to experience a loss of market share. Hence, less investment in indigenous R&D which is the lifeblood of global R&D networks.

Lack of management expertise: Chinese companies have little experience in running or just participating in international companies, and hence few of them are qualified for international R&D management assignments. Overseas returnees have been invited to take a stronger lead, but essentially one of the most important phases of corporate internationalization would thus be carried out by outsiders.

While the domestic market is still strong, there is little incentive to leave China and conquer less attractive markets elsewhere. Among those, developing countries require the least product adaptation but also offer fewer profits, while advanced countries as overseas markets are already highly contested by technology-intensive multinationals, leaving Chinese firms with some less attractive niche markets to begin with. Without size, it is difficult to demonstrate the long-term commitment necessary to conquer foreign markets.

There is no efficiency advantage to go elsewhere for R&D as China is already offering a very favorable price-to-performance ratio for R&D and engineering work. Any local R&D work must be paid for with local revenues, which are generated as local start-up businesses and hence are often reinvested in business development rather than long-term product development.

While younger university graduates speak English better, senior and middle R&D staff has no or little command of English, which is the international language of business and technology. It will take several years before more linguistically trained engineers will have entered the ranks and file to support R&D internationalization (incidentally, many of Haier's middle managers are quite young, i.e. in the late 20s).

Chinese management also emphasizes personal networks ('guanxi') to take decisions and get things done. In international settings, where people are far away from centers of decision making and corporate networks, foreign R&D managers are disadvantaged to support their causes and risk permanent loss of social power if removed for too long. Recent initiatives, such as Dongfeng's 'web-enable R&D systems' are expected to alleviate this problem.

4.4 Strategies of R&D Internationalization

Overall, it seems that truly global R&D in Chinese companies is still a long way away. Current international R&D structures function because of strong personal leadership or because of a military-style command structure. There is little evidence to suggest that foreign R&D networks managed in this manner are sustainable over the long run, but perhaps we are about to witness the creating of a unique Chinese approach to R&D internationalization. Based on the China example, we can make the following propositions:

- Firms from developing countries are more likely to internationalize R&D into advanced countries because of their shortage of domestic technologies, and because of various limitations to serve foreign markets technologically.
- Firms of developing countries will internationalize R&D into other developing countries

opportunistically, i.e. when following local customer requests. As a consequence, they may reap long-term first-mover advantages in less privileged regions of the world.

- Thus, companies with more developed R&D networks create two superimposed R&D networks: one which is innovation capability enhancing, i.e. developing the R&D network's capabilities to understand and conduct cutting-edge technology development by absorbing know-how from advanced countries, and one which is innovation capability exploiting, i.e. passing on technologies and technical know-how which has been absorbed earlier and refined for use in other developing countries.

The innovation capability enhancing/exploiting concept is related to Kuemmerle's (1997) home-base augmenting/exploiting notation, but differs in two important aspects:

1. The unit of analysis is the R&D network and its various coordination mechanisms and interactions, rather than a dyadic knowledge transfer relationship between the overseas R&D unit with its home-base.
2. The focus is on innovation capability and its context-specific actualization, rather than knowledge and information exchanged between R&D units.

5. Future Research

The paper presents research that suffers from several weaknesses, which ongoing research is trying to overcome:

1. The data set is quite limited and biased towards a) Chinese companies and b) IT companies. The population size limitation must be solved by systematically screening all Chinese firms of a consistent criterion (e.g., total sales or total R&D investment). The focus on Chinese companies offered greater in-depth analysis, but limits the potential to generalize the findings. Similar research needs to be conducted in other countries of similar economic development. The bias towards IT companies is representative of the greater international R&D involvement of Chinese IT companies.

2. The use of R&D units is not a perfect proxy for real R&D internationalization, as a) the average size of R&D units in China may be different from the average size of R&D units elsewhere, and b) the denotation of R&D in China may differ from international usage. Data on R&D investments and staff deployment are, however, difficult to obtain systematically.

3. With respect to the 2x2 matrix of the four types of international R&D research, the selection of parent companies for inclusion of R&D sites of their international subsidiaries must follow globally consistent and reasonable criteria. The current data of international R&D locations has been collected using the top companies of developing countries and benchmarking them against top companies of advanced countries. Although the latter group is much larger than the former, it must be ensured that companies are considered for the same reason and up (or rather) down to a certain level of e.g. annual turnover or R&D investment. Research is ongoing to compensate for this shortcoming.

This paper is thus still preliminary in its analysis, and the suggested findings must be considered in the light of these weaknesses.

6. Conclusions

In this paper, the argument was made that internationalization of R&D from developing countries is on the rise. Four types – and phases – of international R&D research were discerned. As an example of type 3 & type 4 R&D internationalization, Chinese companies illustrated some of the motivations, strategies, and difficulties that such companies face. More research is required in terms of deepening the research in Chinese technology-intensive firms as well as companies from other developing countries such as South Korea and India, to develop better models and more knowledge about this relatively recent phenomenon. While this research is still incomplete and the conceptual development ongoing, this paper attempted to offer a new framework to analyze international R&D management research as well as a new perspective on specific management models of R&D in developing countries.

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