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Abstract

Purpose – The purpose of this paper is to open a new research frontier concerning industry factors influencing R&D transfer to emerging markets within Western multinational companies (MNCs).

Design/methodology/approach – The paper presents a framework based on knowledge transfer, knowledge creation, and innovation theory, which is illustrated in two cases from globally leading MNCs from different industries and technological fields which have established R&D units in China. It addresses the issue of industrial influences on R&D transfer to emerging markets, and the importance of complementary assets for innovation performance.

Findings – The framework and empirical research suggest that R&D transfer to new R&D units in emerging markets is less challenging for companies within industries characterized by slow technological development. This is due to dynamics, which result in codification and diffusion of technical knowledge, whereby it is easier to transfer and absorb. When the transformation from exploration to exploitation of knowledge is simple rather than complex within an industry, R&D transfer is less challenging. Leverage of local complementary assets nurtures reverse R&D knowledge transfer – positively impacting innovation performance.

Originality/value – The paper addresses the gap in knowledge transfer theory concerning industrial R&D transfer differences. The paper provides a framework for innovation related industrial contingencies on R&D transfer concerning emerging markets, and it advances the argument that complementary assets are important for R&D in emerging markets. Implications for management in China are outlined. The term captive knowledge transfer is coined.

Keywords Innovation, China, Research and development, Knowledge transfer, Emerging markets

Paper type Research paper

1. Introduction

China has become a major attractor of foreign R&D (Yifei et al., 2007) in spite of the knowledge gap which still exists between China and the West in many technological areas, and which has been further exacerbated, e.g. by the Cultural Revolution, where the existing critical mass of research talent in China was spread around and most research institutes and universities were closed down (Simon, 1989). Another historical legacy which has contributed to the creation of the knowledge gap can be explained by applying the framework developed by March (1991) where exploration can be considered an activity which can result in the development of new knowledge. Exploitation, on the other hand, can be considered an activity which makes use of knowledge. Confucianism and other cultural and historical factors have developed a preference in the Chinese population for exploitation as opposed to exploration. That knowledge creation for the sake of knowledge creation is not a preferred activity in China (Baark, 2007) may further sustain the knowledge gap between China and the West (including Japan). A major objective for the Chinese government therefore concerns technological knowledge transfer to the country (Buckley et al., 2003).

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Different approaches can be leveraged in order to bridge the knowledge gap on a national level. R&D is becoming more and more an international activity within multinational companies (MNCs). MNCs also transfer R&D and innovation related activities to countries such as China (Von Zedtwitz, 2004). It seems evident that foreign R&D centers in China play an important role in China's efforts to become a substantial force in global innovation.

The literature is quite informative in terms of why Western MNCs internationalize R&D activities. The motivations behind this can be, for example, market-driven, production-driven, technology-driven, innovation-driven, cost-driven, or policy-driven (Gammeltoft, 2006). In China, low wages combined with the huge and growing Chinese market is one reason (Gassmann and Han, 2004); obtaining the advantages of having R&D co-located with manufacturing already transferred to China is another (Walsh, 2007). Many other reasons can be mentioned, however, an increasingly important objective for Western MNCs establishing R&D units in China is to get access to the large and growing pool of technical talent (Walsh, 2007; Lewin et al., 2009), which is expected to further develop in China in the future. In spite of the large output of new graduates every year in China from more than 1,000 research institutes and universities with close to six million students enrolled (Chen, 2006) the aforementioned knowledge gap still represents a challenge, although local sources of knowledge can be identified and tapped in China (Harryson and Søberg, 2009a). A difficulty for globalized R&D activities exists in that knowledge may be more likely to flow between people the smaller the geographical distance is between them (Allen, 1977; Allen and Henn, 2006). If the case should be made against globalized R&D, it would be relevant to mention that face-to-face contact is important for the exchange and creation of new knowledge, and therefore globalized R&D may be highly challenging in general (Sölvell, 2003, 2009). In the particular case of China, such barriers can also be identified (Gassmann and Han, 2004; Sun et al., 2006). In order for Western MNCs to bridge the knowledge gap in China and contribute to innovation performance, it is necessary to transfer knowledge to R&D units established in emerging markets, such as China. Although we know that R&D investments in China tend to be concentrated within high technology industries such as biotechnology, chemicals, software, and telecommunications (Li and Zhong, 2003), we do not know if and why the challenges of globalized R&D may differ in intensity across different industries.

Knowledge transfer is particularly interesting to inquire into – and also particularly challenging in managerial situations where a substantial knowledge gap exists. In the case of foreign invested R&D centers in China, such situations are commonplace. Whereas industries have served as the reference point for the foundation of a school of thought within the strategic management field (Bain, 1965; Porter, 1981, 1996), inquiries pertaining to industrial differences are less common within the R&D management field. This paper therefore opens a new research frontier concerning industry factors influencing R&D transfer to emerging markets, and it further investigates the role of complementary assets in relation to innovation in emerging markets. Therefore, a framework relevant to this end is presented and applied in the analysis of two cases of R&D transfer to China within MNCs, which are global leaders within their industries, before relevant implications and conclusions are outlined. The focus is primarily on captive knowledge transfer, meaning knowledge transfer which takes place within fully owned parts of a company.

2. Theoretical framework

2.1 Knowledge transfer

A number of factors may influence the extent to which knowledge transfer is easy to do. In general, the more codified knowledge is, as opposed to tacit (Polanyi, 1966), the easier it is to transfer (Teece, 1986, 1998). "Sticky" information is costly to acquire, transfer, and use with the purpose of technical problem solving (Von Hippel, 1994). Similarly, "Internal stickiness" characterizes factors hindering the transfer of knowledge (Szulanski, 1996, 2000). It can concern relational factors between the sender and the receiver in terms of motivation (Kalling, 2003), and also factors associated with the recipient's lack of "absorptive capacity" (Cohen and Levinthal, 1990; Szulanski, 1996; Gupta and Govindarajan, 2000; Minbaeva et al., 2003; Chen, 2004; Wang et al., 2004). "Absorptive capacity" is the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990; p. 130). Knowledge transfer can be described as "a process in which an organization recreates and maintains a complex, causally ambiguous set of routines in a new setting" (Szulanski, 2000, p. 10). Knowledge transfer and knowledge creation goes hand-in-hand for several reasons. Although the location specificity of knowledge may vary across different types of business activities (Anand and Delios, 1997), knowledge often tends to be local (Hayek, 1945). If knowledge is local it may be necessary to re-create it in order to transfer it. The experiential character of knowledge (Penrose, 1995) may be an important reason why absorption of R&D related knowledge and information is easier for a company doing R&D, than for a company not doing R&D (Cohen and Levinthal, 1990).

Valuable knowledge creation contributes to the innovation performance of companies; however, in a newly established R&D unit in an emerging market, knowledge transfer to the unit, may be required before creation of new knowledge can commence. Knowledge flows to and from a subsidiary can be categorized as primary, secondary, and reverse knowledge transfer. Primary knowledge transfer is the transfer of knowledge from a head quarter to a subsidiary, secondary knowledge transfer is the transfer of knowledge between subsidiaries, and reverse knowledge transfer is the transfer of new knowledge from a subsidiary back to the head quarter (Buckley et al., 2003). Primary knowledge transfer supports the development of an understanding of the existing state-of-the-art, in a new R&D unit in an emerging market, thereby decreasing (or leveling out) the knowledge gap, which might otherwise inhibit knowledge creation and reverse knowledge transfer from such R&D units.

Focusing on manufacturing technology, Teece (1977) measures the cost of transfer as the value of the resources utilized in order to successfully transfer technology. A company which is good at transferring technology at a low cost may be good at primary knowledge transfer. However, if the purpose of a new R&D unit in an emerging market is that it should be able to contribute to the innovation performance of a company in terms of valuable reverse knowledge transfer, the purpose of knowledge transfer is not likely to have been fulfilled simply when knowledge, e.g. in terms of technology, has been transferred to a new R&D unit. The R&D unit should also be able to contribute to the existing knowledge, not merely be able to understand it. The ability to do so may be influenced by certain industrial factors.

2.2 Why slow technological development eases R&D transfer

Old technology tends to be less costly to transfer, because it is often more codified than new technology (Kogut and Zander, 1993). Emergent technologies tend to be uncodified and undiffused, key technologies tend to be codified and undiffused, whereas base technologies most often are diffused and codified (Boisot, 1995). Within industries having fast technological development, new emergent technologies are likely to dominate, and hence R&D knowledge is likely to be uncodified and undiffused and thereby more difficult to transfer. The opposite is likely to be the case within industries having slow technological development for a number of reasons. Merely to have access to valuable technical information is not enough to understand it in its totality. Information access may assist knowledge creation, however, in order to develop absorptive capacity within a technological area, it is, as mentioned above, often necessary to do R&D within this technological field (Cohen and Levinthal, 1990) whereby technical know-how needed in order to understand knowledge and information of a more complex kind can be developed. This being said, foreign invested R&D units in emerging markets may have an easier time improving the knowledge level of their employees if technical information is easy to access. In the following, the focus will be on the impact on primary knowledge transfer and knowledge absorption of such industry factors as patent intensity and the intensity of tests required for innovations to be approved within industries.

2.2.1 Intensity of tests required for innovations to be approved eases primary R&D knowledge transfer. Within many technical industries, it is necessary for competitors to find a common ground in terms of technical and other industry standards in order for the industry to function in a good way for the different competitors within the industry, as well as their customers. For instance, customers of an industry may have certain demands in terms of interoperability (Jardim-Goncalves et al., 2006; Dahlberg et al., 2008) of products, provided by different competitors within the industry. If an industry is unable to meet such customer demands, the products provided by an industry may be less attractive for its customers, and the industry itself may be a less attractive place to do business for a company. This can serve as examples as to why collaboration needs to take place before competition can begin (Glimstedt, 2001a, b). Some industry standards are induced by the industry itself and others are enforced by other authorities. One type of industry standard concerns the tests new innovations need to go through in order to be allowed in the market. Such standards may influence new product development time and thereby, possibly, also to some extent influence the speed of technological development within an industry.

In industries where extensive test procedures need to be carried out in order for a new innovation to be approved, knowledge is also likely to be more accessible, because the companies need to be able to provide documentation of new innovations to external parties in order to get them approved and accepted in the marketplace. This may force companies to invest in and establish procedures for the codification of R&D knowledge, whereby it may become easier to transfer than it would otherwise be (Kogut and Zander, 1993). On the other hand, tests take time and they may slow down technological development.

2.2.2 Patent intensity eases R&D knowledge absorption. Industries characterized by slow technological development tend to invest more in the protection of important knowledge assets in order to make it difficult for companies other than the innovating company itself to profit from new innovations, since more time is available to profit from investments made in new innovations as well as investments made in the protection of these innovations against competition (Boisot, 1995). Also, less uncertainty may exist in terms of whether a technology risks being outdated sooner than investments in its protection have proved to be worthwhile, if the technological development is slow, as opposed to fast, within an industry. Some companies may choose to protect their knowledge assets by means of secrecy instead of patents and other types of intellectual property rights which in some cases is recommendable (Kumar and Ellingson, 2007). However, this is difficult, since product knowledge and process knowledge has to be shared with customers and suppliers, respectively. Also, for different reasons such as the existence of industry norms, both of these types of knowledge are often available for competitors (Boisot, 1995). Therefore, secrecy is not an easy strategy to carry out in order to protect valuable knowledge assets and patents, and other types of intellectual property rights may constitute a better alternative.

In order to get a patent granted, all relevant information about an invention needs to be shared with the rest of the world, in terms of exhaustive technical description. As a consequence, of this, the vast majority of all information which can be found in patents and utility models is publicly available in no other places than in patent databases and archives (Cohausz, 2004). So it is no surprise that patents emanate valuable technical knowledge (Boisot, 1995). In summary, industries with slow technological development are likely to be more patent intensive and valuable technical knowledge and information is therefore likely to be more codified and accessible within these industries, e.g. in patent databases, than it would otherwise be.

Differences in intellectual property rights legislation across countries may impact different industries differently. Within the pharmaceutical industry, the market in the USA is normally very important, and therefore it is important to have patents there. A special characteristic of the intellectual property rights legislation in the USA is that it is important to be the first to invent, rather than being the first to file a patent for a new invention. Simply put, companies need to be able to document that they have invented something and when, and they also need to show that they have continued to work on it in order not to lose their opportunity to get a patent granted. Therefore, companies who wish to get patents granted in the USA are forced to continuously document the ongoing R&D activities. This is likely to make R&D knowledge more codified, and therefore easier to transfer within and beyond the company.

The patent literature, in terms of databases, is equally available across the globe, as long as internet access is available. It is therefore likely that information and knowledge relevant for R&D activities is easier to find in relation to industries of high patent intensity than it may be within other industries. However, patents as a source of information relevant to assist knowledge creation are likely to differ in importance across industries. Patents are not made public until 18 months after their filing, and within industries of fast technological development, such information may already be outdated. However, within industries of slow technological development, patent databases may be more valuable sources of information.

2.3 Transformation from exploration to exploitation

As previously outlined, exploration can be defined as creation of new knowledge, whereas exploitation simply put, can be defined as the use of knowledge (March, 1991). R&D activities are maybe more concerned with exploration than exploitation; however, both of these activities may be required for innovation to come about. Exploitation is likely to be a subsequent activity to exploration although iterations also may occur; however, the transformation from the exploration phase to the exploitation phase of innovation may not always be simple to handle. Moreover, the extent to which transformation between exploration and exploitation is complex as opposed to simple and may vary across industries. Software is easy to distribute through the internet, and it does not need to be manufactured (Teece, 1998). In relation to software development, the transformation from exploration to exploitation may therefore often be simple rather than complex. This may be similar to the chemical industry and the pharmaceutical industry (Harryson and Søberg, 2009b). Within mechanical engineering industries, the picture may, however, be different. Transformation between exploration and exploitation describes when knowledge is transferred from ideas to manufacturing, marketing and other complementary skills (Kogut and Zander, 1993). Especially, when this is complex, it may require experience as well as good networks bridging groups of people having diverse and complementary skills (Harryson, 2006) – two things which most often accumulate over time and therefore represent a challenge for new R&D units in emerging markets, unless they are provided, e.g. in terms of expatriates.

2.3.1 Complementary assets. For big and small companies alike, fast technological change and increasing sophistication of technology can make it impossible for a company to possess all the skills as well as complementary assets needed to commercialize innovations effectively (Teece, 1986). Complementary assets may not play a direct role in knowledge creation as such, but whether or not they are available may determine whether created knowledge can be packaged into services and products which can yield a value (Teece, 1998). What complicates the transformation from exploration to exploitation might often be dependence on specialized and maybe idiosyncratic complementary assets which are necessary to commercialize innovation. What may further complicate global R&D is that complementary assets relevant for innovation related activities, such as idiosyncratic test facilities, may not necessarily be equally available across the globe. For instance, it is easier in China to get access to large test populations for medicine than it may be in other locations (Boutellier and Ullman, 2007).

The framework is summarized in Figure 1, which outlines important industrial factors influencing R&D transfer to emerging markets within Western MNCs. The main hypothesis is that R&D transfer to emerging markets within Western MNCs is less challenging in industries characterized by slow technological development and simple transformation from exploration to exploitation in relation to innovation than it is in industries characterized by fast technological development and where transformation from exploration to exploitation is more complex.

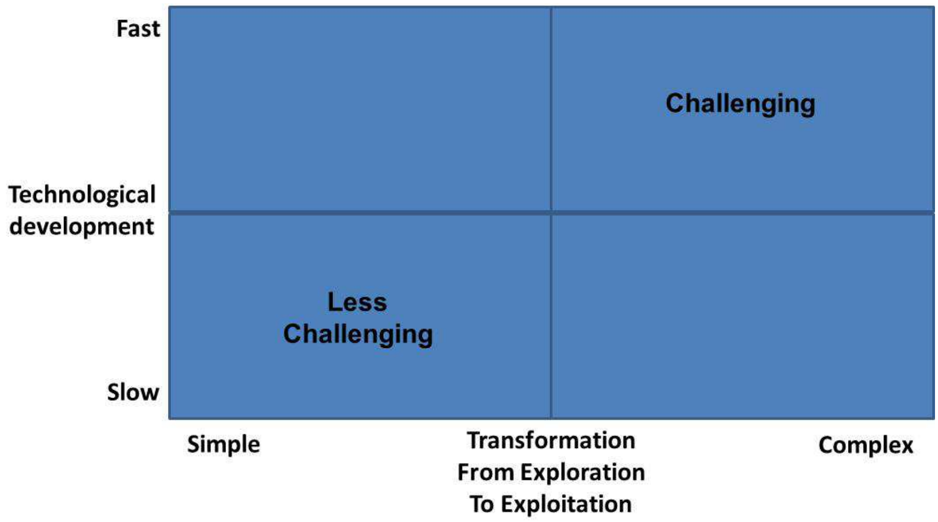

Figure 1. Industry factors influencing R&D transfer to emerging markets within Western MNCs

Based on the literature presented above, it may be possible to hypothesize a distribution of industries in the matrix as outlined in Figure 2. Figure 2 is only presented here in order to provide an example of how it is possible to make use of the matrix rather than illustrating empirical research. Instead, the framework will be put to work in the case presentation, and analysis.

3. Methodology

Since this holistic multiple case study incorporates companies from different industries, it constitutes a good foundation for the development of theory pertaining to R&D knowledge transfer differences across industries in relation to foreign invested R&D in emerging markets.

The abductive approach is the methodological strategy behind this research project. This approach emphasizes theory development as an iterative process of matching theory with reality and vice versa – walking back and forth between empirical findings and theoretical framework – whereby both co-evolve. Empirical findings triggered a search for further theories whereby a continuous interchange and pattern matching (Yin, 2003) between empirical data and theory took place in order to secure good empirical support for the theoretical framework.

The basis for this process is an exploratory holistic multiple case study (Yin, 2003) including extensive qualitative empirical material collected from two Scandinavian companies which were chosen due to good access to the companies, due to the fact that they are global R&D intensive companies, and due to their leading positions, on a global scale, within their respective industries. For inquiries into complex social phenomena, case studies are preferable (Yin, 2003). More than 20 semi-structured qualitative interviews have been conducted, with the case companies in the period from January 2007 to March 2010. Interviews have been conducted in several rounds in order to facilitate insights concerning how the cases develop over time. Interviews took place in person as well as on the telephone. They normally took around one and half hours and they were all recorded and fully transcribed. R&D employees from both China and Scandinavia were interviewed. Interviews were conducted with managers in charge of the overall R&D transfer process on different levels, as well as with expatriates and scientists working with R&D in the case companies. The interviewees

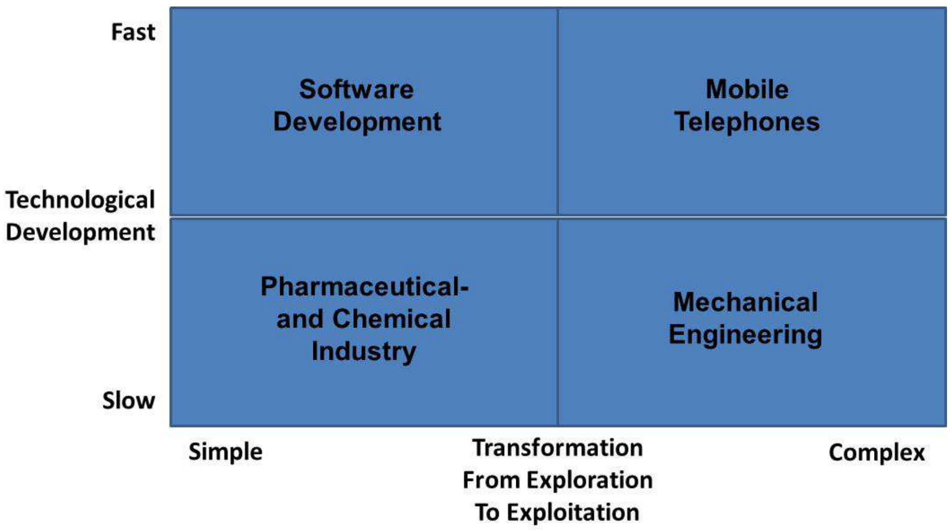

Figure 2. Example of a plot of industries according to industrial factors influencing R&D transfer to emerging markets within Western MNCs

predominantly have technically oriented educations at Master’s or PhD level. In relation to six of the interview sessions with local Chinese scientists who are working for Med Tech in China, a native speaking Chinese PhD student, who is also a good friend of the author, was made use of in order to make it possible for the interviewees to speak freely in their maternal language, which is likely to make it easier for the interviewees to express themselves without being inhibited by language problems (Marschan-Piekkari and Reis, 2004). The interview questions relate to R&D transfer in particular as well as broader questions concerning innovation challenges in general for the company, including the role of the new R&D unit in relation to these innovation challenges. Questions are also asked concerning networking and interaction within and beyond the company in relation to R&D activities, and related problems such as, e.g. intellectual property related issues. As a consequence, of within case and especially cross case analysis, as indicated above, the theoretical framework coevolved from the empirical data and relevant existing theory.

The empirical data are mainly of a primary kind however, secondary data have also been collected. Through the use of multiple sources for the case studies, internal validity has been addressed for the case studies in terms of number of interviewees and their positions in the organizations. The issues of construct validity and reliability have been addressed as key informants have reviewed the case reports. External validity is enhanced by covering two relativity different industries and by developing a relatively industry independent theoretical framework using the abductive approach outlined in this section.

4. Cases

Both case companies are impressed with the good theoretical understanding and hard-working attitude of the Chinese engineers working in the companies, and managers within the companies express their contentment with the establishment of R&D units in China.

4.1 Med Tech

The company established the R&D unit in Beijing at the end of 2001. Important objectives with the establishment were to:

- show commitment and willingness to develop China technologically, in order to please the Chinese government and ease the further growth of the company in China;
- reach the developing talent pool in China; and
- develop a state-of-the-art biotech center in China.

In the long run the company also wishes to identify potential collaboration opportunities within China in the R&D field. Today, the R&D unit employs around 60 scientists. The R&D unit is preoccupied with the earliest stages in the development of new products, primarily based on protein research, often making use of bacteria. The R&D activities conducted in the unit include the identification of new targets for new drugs, validation of potential drugs, and improvements of existing products.

Scientists within the R&D unit sometimes go to conferences in order to get new inspiration.

Some Scandinavian expatriates have been located in the R&D unit but this is not taking place continuously.

4.1.1 Speed of technological development. Intensity of tests required for innovations to be approved. Normally, new products take three to four years to develop and a further nine years are spent on the approval process which is done using documentation and auditing systems which comply with the requirements of FDA (Food and Drug Administration in the USA). This gives a new product development time of approximately 12-13 years.

Patent intensity. The company files many patents. Employees participate in patent courses and make use of the patent literature in relation to their projects in terms of reading valuable patents within their area of research. There is good communication with the patent organization of the company and one person is appointed to take care of patent applications from the Chinese R&D unit. Other companies within the industry are generally trying to file many patents.

4.1.2 Transformation between exploration and exploitation. The R&D unit in China experiences problems in terms of getting access to certain reagents/materials. Some reagents/materials are not available in China and need to be imported from outside which can take several months. Manufacture of the products of the company is generally conducted by the company itself.

Complementary assets. Most of the initial ideas for new products of the company come from academia. In its home country, the company has extensive university collaboration going on. The R&D unit in China is involved in collaboration with universities in terms of student internships which are targeted at fourth-year bachelor students or second-year Master students. These internships most often last between four and six months. Professors from Chinese universities are also sometimes invited to give seminars. The company donated three million US Dollars to the Chinese Academy of Science. It is anticipated that it would be beneficial to have more collaboration with universities in the future, also because it is anticipated that the Chinese universities will improve a lot which will make it worthwhile to have more extensive collaborations going on. The collaboration projects which are going on now are mostly decided by top management, and some scientists express the opinion that it would be more productive if scientists could take the initiative to collaborations individually.

As previously mentioned, complementary assets in terms of test populations are readily available in China. It remains somewhat unclear to what extent this complementary asset is exploited by the company, but it seems to be done to some extent.

4.1.3 Innovation performance. In terms of new innovations created in the R&D unit in China, the following can serve as examples:

- Improvement of a protein purification process, which has dramatically increased productivity.
- Improvement of an assay development process, significantly enhancing assay reproducibility.
- Improvements of production procedures for compounds to be used in cell-based bioassays.
- Development of a new process, from cloning to purification, for production of enzyme – an ingredient in the hormone drugs of the company, making it

unnecessary for the company to buy enzymes from suppliers who sometimes use the flu virus to produce the enzymes which can be unsafe.

In relation to the first three examples mentioned above, already existing project protocols have been provided from the Scandinavian part of the R&D activities of the company, but the processes were not working satisfactorily when the Chinese R&D unit received these.

4.2 Mechanic Tech

In the beginning of 2005, the company initiated R&D establishments in China. The R&D unit in focus in this paper was established by the end of 2006 in order to increase global footprint, enable sourcing in low-cost countries; adapt existing products to the Asian market, support local manufacturing, and in order to develop new products by making use of the large pool of Chinese engineers. Some activities are located in Beijing, however, today 70 engineers are working with R&D activities in Shanghai, primarily focusing on automation equipment. Scandinavian expatriates are continuously located in the R&D unit.

4.2.1 Speed of technological development. Within the company, new products are developed within time ranges of six months to two years.

Intensity of tests required for innovations to be approved. It varies a bit, which tests are needed depends on the product, but the test and approval procedures never last longer than two months in all. The tests are conducted by third parties. In Europe, the products of the company have to live up to strict and standardized security requirements. In Asia, however, the security requirements are less restrictive. Otherwise, the products of the company are quite similar across the globe.

Patent intensity. The company files patents but the trend is to require that a good potential business case is available before patents are filed. If an invention is not integrated in a product within a short time horizon, the patent will be discontinued.

The extent to which other companies within the industry files patents intensively varies from company to company.

4.2.2 Transformation between exploration and exploitation. The company sources all parts for its products from suppliers and in China it has been difficult to find good suppliers who can deliver parts of good quality in a reliable way. This results in a lot of delays and it is frequently necessary to control shipments from suppliers. It is not necessarily so that good suppliers cannot be found in China but the volumes of parts demanded by the company may not be big enough to attract the best suppliers with the best equipment in China. However, even though the Chinese engineers in the R&D unit are highly technically talented, it is difficult for them to manage the R&D projects and the coordination with the suppliers. So far they have not succeeded very well with this and it has been necessary for the Scandinavian part of the R&D organization to support a lot, in order to finish projects so the products can be mass-produced.

Complementary assets. The company does collaborate with universities, however, some national science initiatives in China are perceived by the company as being rather unrealistic and not anchored in real needs. The company provides technical equipment to universities in China in terms of company products for the university students to play around with and ideally to develop preferences for.

4.2.3 Innovation performance. Two patent applications have been filed on inventions made in the R&D unit in China. So far, no major breakthroughs have been created in the R&D unit but it is anticipated that they will come at some point in the future.

5. Analysis

Table I compares the case companies along several dimensions making use of the words high, medium, and low, along with other information which will be further clarified subsequently in the remaining part of the analysis following Table I.

5.1 Speed of technological development

The development and approval process of new products is much longer for Med Tech than it is for Mechanic Tech as indicated in Table I.

5.1.1 Intensity of tests required for innovations to be approved. For Med Tech, the innovation approval requirements are intense, since the company complies with the medical requirements of, e.g. FDA. The company, therefore, needs to be able to document for FDA that they are living up to the requirements. As exemplified in the case, extensive protocols of innovation related activities of the company seem to exist. Since this knowledge is highly codified, it can more easily be transferred to China, where, based on these protocols, scientists can try to improve the processes described in the protocols. For Mechanic Tech, the requirements seem less intense in comparison as indicated in Table I, and the company is therefore not forced to codify parts of its R&D knowledge to the same extent in order to live up to industry requirements. R&D knowledge may therefore be less codified and more difficult to transfer to China than within Med Tech.

5.1.2 Patent intensity. The technological development within the industry where Med Tech is active seems to be slower that it is within the industry where Mechanic Tech is active, as indicated in Table I. Mechanic Tech is selective in terms of what they file patents for. Med Tech is operating within an industry which is more patent intensive than Mechanic Tech. The employees of Med Tech seem to make more use of information which they find in patents in relation to their everyday work than seems to be the case for the employees within Mechanic Tech. The patent literature seems to be more instrumental for the scientists within Med Tech, in order to develop their own knowledge, than it may be for the employees working for Med Tech. It may therefore be easier for them to develop their knowledge, since they have access to better sources

	Med Tech	Mechanic Tech
New product development time/time required	High/12-13 years	Low/0,5-2 years
Intensity of tests required for innovations to be approved/time required	High/9 years	Low/2 months
Patent intensity	High	Medium
Degree of locally sourced manufacturing in China	Low	High
Complementary assets benefiting R&D in China	Test populations universities	Universities
I-U collaboration	Medium	Medium
Reverse knowledge transfer	High	Low

Table I. Comparison of the case companies of relevant information outside the company, which they can make use of in their efforts.

5.2 Transformation between exploration and exploitation

The products of Mechanic Tech consist of parts which in themselves may be more or less sophisticated. The products of Med Tech may be highly sophisticated, but they most often consist of parts which in themselves are not very sophisticated. This may be relevant in order to understand why the transformation from exploration to exploitation seems to be more complex for Mechanic Tech than it is for Med Tech, and it may therefore require more experience as well as good personal networks, which is difficult for a new R&D unit in China to contain since these things may require time to develop. Expatriates may be instrumental in terms of overcoming such deficiencies, and it is interesting to see that expatriates are far more common within the Chinese R&D unit of Mechanic Tech than within the Chinese R&D unit of Med Tech. In China the high extent to which the company makes use of local sourcing in their products may further complicate the transformation from exploration to exploitation, due to problems experienced in terms of identifying suppliers who can deliver sufficiently high quality.

Taking the initiative with other people may be important in terms of succeeding with the transformation between exploration and exploitation, since it is likely to require orchestration of a multitude of skills from diverse groups of people. This is a problem within Mechanic Tech. Taking the initiative with other people was initially a problem for Med Tech as well, however, the problem previously materialized in the exploration phase rather than in the transformation between exploration and exploitation.

5.2.1 Complementary assets. For Med Tech, a new complementary asset in terms of easy access to large test populations is available in China which is unavailable in Scandinavia. Both companies collaborate with universities in China to some extent, and Med Tech expects to be able to reap further benefits of this in the future. For Mechanic Tech, universities in China seem so far to contribute very little to the R&D knowledge creation in relation to the Chinese R&D activities of the company.

5.3 Innovation performance

Although the development of new products and concepts is one objective behind the establishment of R&D of both companies, so far Med Tech seems to have been the most successful on this front. It can be argued that the company has conducted R&D in China longer than Mechanic Tech, and the R&D employees may therefore be more experienced, however, this is not likely to be the only reason for the apparent differences in innovation performance and reverse knowledge transfer as indicated in Table I.

Three of the mentioned examples of innovations done within the Chinese R&D unit of Med Tech are innovations, where the Chinese scientists have significantly improved existing processes within the company, based on existing project protocols, which they have received from the Scandinavian part of the R&D activities of the company. It seems that at least part of the success created by the scientists within Med Tech in China has only been possible because much R&D knowledge is highly codified within the company and therefore easier to transfer. Also, much R&D relevant information and knowledge seems to be available by searching in patents and other literature, by going to conferences, and working in the lab, etc. the scientists within Med Tech can develop relevant knowledge in order to innovate and further improve the processes and products of the company (Figure 3).

Figure 3 summarizes the analysis, and illustrates that it is less challenging for Med Tech to transfer and create R&D knowledge within their Chinese R&D unit than it may be for Mechanic Tech.

6. Implications

6.1 Managerial implications

For managers considering where to locate R&D on the globe, it may be relevant to take into account the extent to which complementary assets are available (or can be created) in potential locations, since these may be important in order to enable a new R&D unit to contribute to innovation performance.

The extent to which the knowledge gap is difficult to bridge in China differs across industries. It may be easier within industries characterized by slow technological development and simple transformation from exploration to exploitation.

Within industries characterized by complex transformation between exploration and exploitation, it may be particularly important to make use of expatriates experienced in this critical part of innovation activities, and who have relevant personal networks.

6.2 Policy implications

China is likely to make its impact felt most within industries where the complementary assets the country can provide for innovation related activities are most relevant.

6.3 Implications for further research

- Proximity is important for innovation related activities (Allen, 1977; Allen and Henn, 2006; Harryson et al., 2008), which represents an intriguing problem for globalized R&D, however, further research may improve our understanding as to whether proximity is more or less important across industries.
- The framework presented in this paper was developed in relation to two in-depth cases of captive R&D offshoring to China. Future research may attempt to

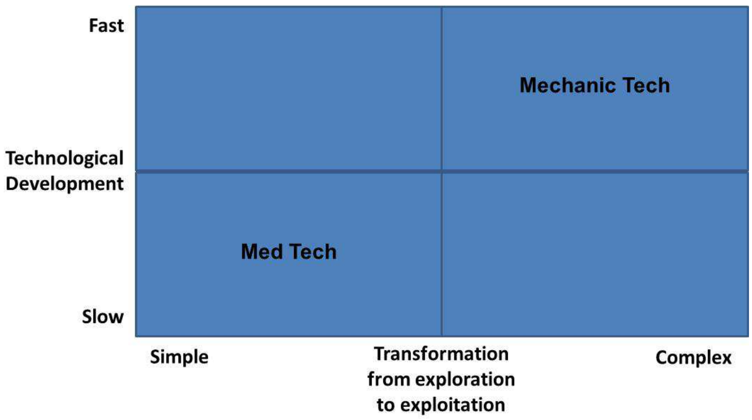

Figure 3. Industry factors influencing R&D transfer to the Chinese R&D units of the case companies

operationalize the presented framework in a survey, and thereby enable a larger sample size of companies and industries in order to further test the framework.

7. Conclusions

Addressing a gap in the literature, this paper has provided a framework concerning industry differences pertaining to R&D transfer to emerging markets within Western MNCs. The developed framework, built on knowledge transfer, knowledge creation, and innovation theory, was illustrated and validated by two cases of foreign invested R&D establishments in China.

Industries characterized by slow technological development may often have extensive requirements in terms of required tests in order for innovations to be approved, and they are often patent intensive. The intensity of tests required in order for new innovations to be approved within an industry makes R&D knowledge more codified and it eases primary knowledge transfer. Within patent intensive industries, information relevant to support R&D knowledge creation, positively impacting innovation performance in terms of reverse knowledge transfer, is easier to absorb. When the transformation from exploration to exploitation is complex within an industry, it may be difficult to perform for a new R&D unit in an emerging market due to lack of experience and lack of relevant personal networks. As illustrated in the case presentation and analysis, R&D transfer is less challenging within industries characterized by slow technological development and simple transformation from exploration to exploitation, than it is within industries characterized by fast technological development and complex transformation from exploration to exploitation. The ability of foreign invested R&D units in China to make significant contributions to innovation performance in terms of valuable reverse knowledge transfer is nurtured if the R&D unit is able to tap into complementary assets in the local environment.

Implications for managers, policymakers and researchers outlined in the last parts of the paper suggest the relevance of paying further attention to differences across industries as well as complementary assets. They further provide inspiration in terms of how to address challenges of globalized R&D in general and particularly in China.

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