R&D Transfer from Europe to Asia - Towards Global R&D Complementarity Benefiting Innovation Performance

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Abstract

Purpose – The paper investigates foreign invested radical innovations, and related impediments, in China and India, in order to better understand impediments and requirements for radical innovation in China.

Design/methodology/approach - The paper presents a framework based on theories on knowledge creation, innovation and networking, which is relevant in order to understand impediments and opportunities for radical innovation in China. The paper also draws on extensive empirical data collected from a holistic multiple case study including three MNCs based in Scandinavia, which have established R&D units in China and India.

Findings – Examples of radical innovations in China and India within Scandinavian MNCs are presented, illustrating that radical innovation is indeed possible in China. However, impediments to radical innovation also exist. A knowledge gap, as opposed to an information gap, exists in China and India.

Originality/value – A deficiency with the existing distinction between information and knowledge is identified. A new distinction between knowledge and information is proposed, which embraces the tacit nature of complex explicit knowledge - or tacit information. Skill requirements, for creating and understanding information and knowledge respectively, are outlined. The framework is relevant in order to understand better, requirements in order for China to step further up the learning curve and innovate in radical ways. Policy implications, relevant for governmental bodies as well as managers in China, suggesting further emphasis on the development of socialization skills and opportunities for experiential knowledge creation, are outlined.

Keywords Radical innovation, China, India, R&D transfer, Tacit information, Tacit knowledge.

Paper type Research paper.

1. Introduction

We need to care more about the differences between knowledge and information, since better understanding of these differences may enable better understanding of why China is not yet a leading country in terms of the creation of radical innovations. In spite of China's proud legacy as the country where such radical innovation as gunpowder, printing, paper and the compass were created (Johnson and Weiss, 2008), China has not had a leading position concerning the creation of radical innovations for a very long time. Instead, Western countries followed by Japan and other countries have been the leading playgrounds for radical innovation. Exploration is an activity, which may result in the development of knowledge and exploitation is an activity, that makes use of new knowledge (March, 1991). If one should pinpoint a country specific preference for China in terms of performing either exploration or exploitation, the latter activity is likely to be the conclusion, due to a number of historical and cultural factors, which may inhibit radical innovation. In China, experiments and knowledge creation for the sake of knowledge creation, have for a long time not been considered important (Baark, 2007), even though these exact activities indeed are important in order to facilitate innovation in general - and radical innovation in particular. However, in spite of these historical and cultural factors impeding radical innovation in China, convincing evidence, as it will also be illustrated in this paper, is starting to build up, which shows that China indeed is capable of radical innovation, if anyone should have forgotten it. It is intriguing how China is able to create radical innovation in spite of the contingent knowledge gap between China and the leading Western countries. Therefore, there might be another lesson or two to be learned about radical innovation in China.

The purpose of innovative activities in a company is to develop means and approaches for solving the problems of customers in ways, which enable the company to create profit. A radical innovation does not necessarily address a new problem, although that may very well be the case, nor does it necessarily make use of new technologies, although that of course also can be the case. What determines whether an innovation is radical or not, is merely the extent to which the innovation fulfills its purpose better than other existing innovations. That is, linking back to the aforementioned purpose of innovative activities within companies, if an innovation enables a company to solve problems in ways, which enables the company to create a lot of profit, for a shorter or longer period of time, we may label this innovation as a radical innovation.

As it was vividly exemplified by Johnson and Weiss (2008) further research is needed in terms of comparisons of innovations between China, other Asian countries and Europe, which is the subject of this paper with a focus on radical technical innovation in China.

In order to investigate Chinese created radical innovations, it is relevant to look inside in the R&D units of foreign originated companies in China, due to the following reasons:

- Foreign invested R&D units in China have access to pools of knowledge within these multinational companies (MNCs), which may improve the opportunities to create radical innovations when compared to the R&D units of domestic Chinese companies, which are not equipped with the same knowledge access. Foreign invested R&D units in China may therefore be a good place to identify - and investigate radical innovation in China.
- Since MNCs, among other things, are characterized by their presence in many different country contexts, they can serve as empirical contexts, which enable interesting comparisons between these country contexts.

This paper therefore sets out to investigate radical technical innovation in foreign invested R&D units with a focus on the impediments to radical innovation and knowledge creation within foreign invested R&D units in China and India.

The reader is therefore presented with a framework based on knowledge creation-, innovation-, and networking theory, which is relevant in order to assist our further understanding of knowledge creation and radical innovation in emerging markets such as China and India. The framework is later applied in relation to the case companies before relevant implications and conclusions are presented.

2. Theoretical framework: Radical innovation as an act of knowledge creation

2.1. The SECI model

By means of organizational knowledge creation companies are able to create new knowledge, which can be disseminated in the organization and embodied in new products and services whereby new innovations come to exist (Nonaka and Takeuchi, 1995). The SECI model (Nonaka and Takeuchi, 1995, Nonaka and Konno, 1998) includes the four processes Socialization, Externalization, Combination, and Internalization where explicit knowledge and tacit knowledge is exchanged and transformed in a spiraling knowledge process. In this model, knowledge follows a cycle in which tacit knowledge is transformed into explicit knowledge, and explicit knowledge is “re-internalized” into tacit knowledge. Experienced action and accumulated insights are words describing tacit knowledge, which can also be divided in two dimensions, one being "know-how" and the other one being a cognitive dimension concerning how the world is perceived. A strength of the SECI model, is that it emphasizes the importance of self-transcending human interaction and joint activities for knowledge creation and innovation to take place. Socialization concerns the step where tacit knowledge is shared between individuals (Nonaka and Konno, 1998). The value of the know-how or the tacit knowledge a person has developed and therefore stores within himself is restricted by this person's own perception of the know-how. By empathically transcending oneself and sharing the know-how with others, who in turn also are able to emphasize with the communicator, the knowledge is externalized, and new knowledge can be created. When tacit know-how is shared with others, it is exposed to other cognitive perception mechanisms, which may facilitate new interpretations of this know-how and thereby new knowledge may come into existence. If knowledge is perceived in a new way, it may change the knowledge to something new, which is why it is beneficial for knowledge creation within organizations to be able to reach different worldviews (Miesing et al., 2007).

2.2. The Information Space

In the Information Space (Boisot, 1995a, Boisot and Child, 1999), chaos is seen as the source of innovations, since chaos is characterized by diffused knowledge, which is not abstract nor codified (Boisot, 1995a), and by applying the distinct and mutually reinforcing strategies of codification and abstraction, an innovation can be developed from this knowledge. The degree to which knowledge is fully documented or expressed in writing describes the extent to which it is codified (Hansen, 1999, 87). Codification gives data form by assigning them to categories. Abstraction provides structure since it reduces the amount of categories data needs to be assigned to before a phenomenon can be understood (Boisot and Child, 1999). In the context of technical development we may see abstraction as something which connects means, in terms of relevant technology - or codifications, and ends, in terms of relevant customer problems - and problems in general.

2.3. *Information and knowledge*

Nonaka and Konno (1998) define information as something, which is tangible, which can reside in networks and media, and which can be communicated independently from its original context. They claim that knowledge is intangible, and it is transformed into information, when it is separated from its context (Nonaka and Konno, 1998). Codified knowledge is generally considered explicit, and uncodified knowledge tends to have a higher propensity for being tacit. Nonaka and Konno (1998) would agree that explicit knowledge can be more or less complex, however, their distinction between explicit knowledge and complex explicit knowledge, does not fully embrace the fact that highly explicit codified knowledge is in fact tacit to the person, who does not understand the code (Hansen, 1999). The origin of this problem is likely to reside in the definition of explicit knowledge.

> *"Explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formulae, specifications, manuals, and the like. This kind of knowledge can be readily transmitted between individuals"* (Nonaka and Konno, 1998, 42).

It is problematic that this definition of explicit knowledge incorporates both spoken words and written documents, thereby making the definition rather broad. For a person unable to understand a code, which is required in order to read a document, explicit knowledge may be little different from tacit knowledge, and thereby the definition does not provide a clear distinction between explicit knowledge and tacit knowledge.

Possibly, it would be better to restrict knowledge to the knowledge a person can accumulate and store - or express by the use of his/her body. Quite big differences exist between spoken words, which include nonverbal communication, and for instance a written text, and therefore it may be easier to label written text as information instead of explicit knowledge. When spoken words are put on paper in a written text, much of the communication may be lost due to the codification, which takes place. Some data are unavoidably sacrificed during codification (Boisot, 1995b). What transforms knowledge into information is codification on the one hand, and on the other hand the shift in the means of storage from a human being, to a means of storage, which is able to store information - such as a written document. Whereas information can be stored in various types of artefacts, knowledge can (so far) only be accumulated and stored in human beings. Information is generally explicit, but it may be tacit to the unskilled eye. Knowledge, on the other hand, is socially embedded and it is explicit to the extent one has the socialization skills to reach it, and it is tacit to the extent one is unable to reach it

Figure 1 explains differences between tacit information and tacit knowledge respectively and it outlines skills required in order to create - and understand different types of knowledge and information, which are important for creation of radical innovation.

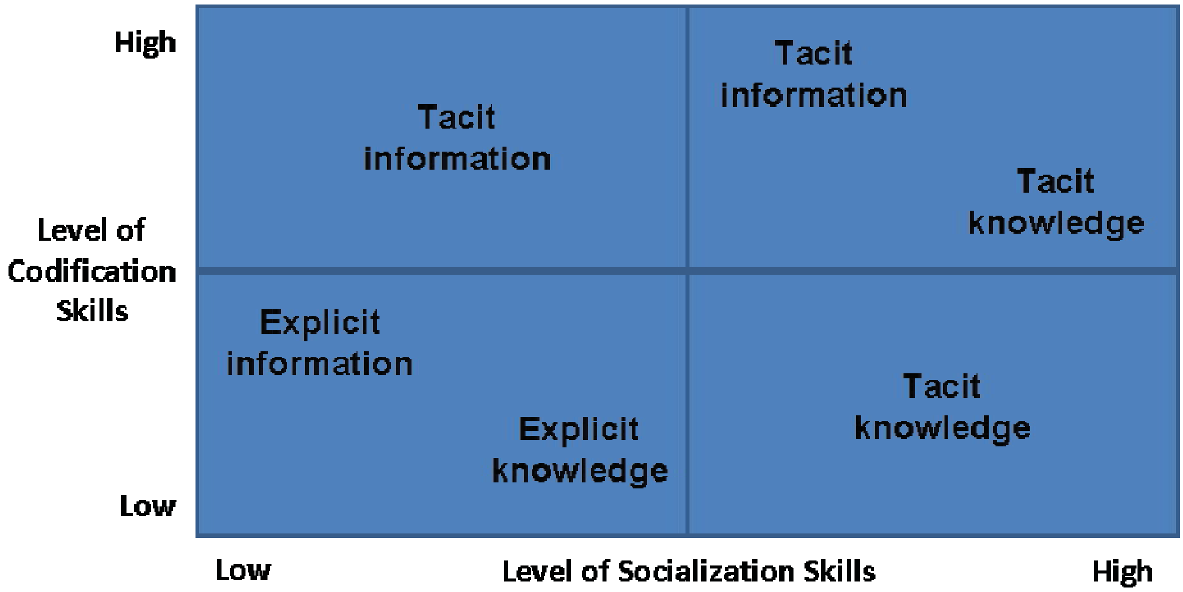

Figure 1: Skill requirements, for creating and understanding information and knowledge (Source: own).

Codification decreases the number of perception channels needed in order to understand knowledge and it transfers the center of ambiguity from the knowledge itself to the code applied. That is, the extent to which information is tacit depends upon the ability to understand the implicit code. On the other hand, socialization skills may be important for a person to understand knowledge stored in other people, and it may also be an important determinant of a person's ability to create knowledge with other people. Socialization skills may be important for an engineer in order to be able to emphasize with customers in terms of understanding the problems they face. Also, they are likely to be important in order for him/her to be able to collaborate with other engineers etc. The better codification skills an engineer has, the more information is possible for him to understand, and therefore he may have access to a wider or more sophisticated spectrum of possible technical solutions to make use of, in order to solve the problem(s) at hand, once he has understood the problem(s) he is trying to solve.

2.4. Availability of information and knowledge

Tacit information is available by means of the codification skills required in order to facilitate internalization of the information. Tacit knowledge is available by means of socialization. Some forms of tacit information can of course also be available by means of socialization in the sense that as a result of socialization, social bonds may develop to an extent where people share information they would otherwise not share. However, for this information to be available in the mind of a person, who has accessed it, internalization of the information is still required and this is possible only if the needed codification skills are mastered. An example of tacit information can be computer code. If you do not know the code, then this information is tacit. The information is not sending a message to your brain, which you are able to make sense of, hence the information is tacit to you.

Following Nonaka and Konno (1998, 40) knowledge creation is likely to take place in “a shared space for emerging relationships”. Weak ties are beneficial in order to identify sources of information and knowledge, which can be tapped in other parts of a company (Hansen, 1999), however, Chinese people have historically adapted to their complex and uncertain environment by forming strong ties with few people, which is different from the West (Boisot and Child, 1999). The question is, if this historical adaptation in China constitutes an impediment to radical innovation, in terms of a small propensity to reap the benefits of weak ties (Granovetter, 1973, Ahuja, 2000) e.g. by accessing the knowledge and experience pertaining to innovative related activities stored in the heads of other people? After the methodology part, the theoretical framework presented here will be applied in relation to some interesting cases of radical innovation in China and India in order to inquire further into this question.

3. Methodology

Investigating how Chinese and Indian R&D units within Scandinavian MNCs contribute to the global innovation performance of these companies in terms of new radical innovations, is a good platform for comparisons of the different cultural contexts, and thereby it is possible to extract from this interesting case study a better understanding of the impediments as well as opportunities for radical innovation, which may be specific to China. MNCs conducting R&D in both Europe and Asia are very relevant empirical contexts for investigations comparing innovations between China, other Asian countries and Europe, which is also why they have been chosen as empirical context for the purpose of this paper. The abductive approach (Alvesson and Sköldberg, 1994, Dubois and Gadde, 2002) is the methodological strategy behind this research project. The abductive 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 search for further theories whereby a continuous interchange 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, which has been collected from three Scandinavian companies. The case companies were chosen due to good access to the companies, due to the fact that they are globalized R&D intensive companies, and due to the leading positions these companies have, on a global scale, within their respective industries. A case study is a preferable methodological approach for inquiries into complex social phenomena (Yin, 2003, Eisenhardt and Graebner, 2007). 32 semistructured qualitative interviews have been conducted, with the three case companies in the period from January 2007 and March 2010. Several rounds of interviews have been conducted with the case companies in order to be better able to track the development of the cases over time. Each interview normally took around 1 1/2 hours and they were all recorded and transcribed. Mechanic Tech has an R&D unit in China and also a small one in India. Med Tech has established an R&D unit in China, and Green Tech has established an R&D unit in India. In all the case companies R&D employees were interviewed, both in the R&D units in Asia and also in Scandinavia. Interviews were conducted with managers in charge of the overall R&D transfer process on different levels, as well as expatriates and scientists working in the R&D units were interviewed.

Secondary data has also been collected, however, the empirical data are mainly of a primary kind. 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 purpose of presenting quotes from a couple of interviewees is to add verisimilitude and represent a wider network of the different actors, across multiple levels in the cases. The issues of construct validity and reliability have been addressed as key informants have reviewed the case reports. External validity is enhanced by covering three relativity different industries and by developing a relatively industry independent theoretical framework using the abductive approach outlined in this section.

4. Cases

All companies perceive the establishments of R&D units in these countries as successful and they have all succeeded in having very low employee turnover rates.

4.1. Mechanic Tech

The company established the R&D unit in Shanghai by the end of 2006. 12 engineers were initially hired and today close to 70 engineers are working with R&D activities in the unit. The objective of the establishment of the R&D unit in China was to support the local manufacturing in the country, which made it necessary to develop local adaptations of the products of the company.

Some R&D related activities of the company are also taking place in India. In terms of differences between conducting R&D activities in China and India the perception in the company is that the Chinese engineers might claim that they have process orientation and interest, however, Indian engineers are more proficient and genuinely interested in following project processes and procedures. On the other hand the Chinese engineers are perceived as having more individual drive and entrepreneurial spirit than the Indian engineers.

4.1.1. Impediments to radical innovation

The engineering schools in China are perceived to be quite good and the Chinese engineers are very hard working, however, it is not easy for the Chinese engineers to collaborate with others, when they leave the educational system and enter the industry. The Chinese educational system is perceived as being very much focused on the development of individual talents. Engineers in China go through an educational system where they are under a lot of pressure. It is not costly as such to study in China, however, students without top grades, may not be allowed to enter the next level of education, or the best schools. Educations in Scandinavia are perceived to be broader in terms of the skills the students acquire, such that it is possible to get new recruits fast up and running in the company. The Chinese engineers experience problems in terms of taking initiative to collaborate with others. Mostly, they sit and work for themselves rather than interacting with others concerning what they are doing. When there is not much interaction going on, problems are slightly hidden away and project management have difficulty succeeding. It is the perception of the company that this result in deadlines, which are not kept, and it is emphasized that the successful developments, which have taken place in the R&D unit so far, would not have been possible without help from Scandinavia in terms of project management. In terms of coming up with new breakthroughs, the lack of interaction is also considered a problem as outlined in the following quote:

> "*The lonely inventor does not exist anymore. Instead, now it is about groups who are tight and who work together and out of that new breakthroughs emerge*" (R&D Manager, interview, 09022010).

4.1.2. Contributions to global innovation performance

The company experiences significant cost savings on the R&D employees in China. Civil engineers in the company are paid approximately €800 per month and PhDs receive wages in China around €1700 a month, which is much less than the company would have to pay similarly educated employees in the home country of the company. The payment levels are increasing with between 10% and 20% in China, but it is anticipated that it will take many years before the payments levels in China will be similar to the payment levels in the home country of the company. The company is collaborating with local universities. In the Scandinavian R&D hub of the company, the Chinese engineers working for the company are described as extremely receptive. It is anticipated that they will be able to perform at the same level as the Scandinavian engineers in the future. Moreover, concerning certain R&D activities the Chinese engineers are performing at higher levels than the engineers in Scandinavia as illustrated in the following quote:

> "*I think they are partly superior to us concerning development of circuit cards and things which requires hard work. Concerning these things we have relaxed a bit… our schools does maybe not fully support that anymore*" (R&D Manager, interview, 09022010).

In the company, innovation is perceived as being something, which is triggered by problems. Two patent applications have been filed on inventions made in the R&D unit in China. So far no radical innovations have been created in the R&D unit, but it is anticipated that it may come in the future. The Chinese engineers have proven to be very good at adapting existing products to the less sophisticated demands of the local market. Thereby, the Chinese engineers have provided a new perspective on things including the notion that a product does not need to contain as much functionality as possible, things can in fact be good enough, which is a provoking thought to some of the Scandinavian engineers.

4.2. Green Tech

The company established the R&D unit in India by the end of 2006 with 20 engineers and by the beginning of 2010 they are around 70 engineers. Among other things the R&D unit contains expertise concerning aerodynamics, structural design and calculations, finite element analysis, quality control processes, construction and reliability. The strategy of the company is to do R&D across the globe and around the location in India, it is possible to get access to a large competitive and cheap workforce, a resource which is scarce in the home country of the company.

4.2.1. Impediments to radical innovation

In the company the perception is that in order to locate an R&D unit in China or India it is necessary to control the process tightly. The Indian engineers are experienced as having difficulties in terms of making decisions and taking action on their own. It is necessary to tell them what to do, which is in sharp contrast to the typical Scandinavian project manager, who is used to do projects independently, because he is used to do projects from when he studied, and afterwards he has continued to work in a Scandinavian company where you are also very project oriented. At the bachelors levels in the educational system in India, it seems that practically oriented university project are rare, however, at master level it may happen. In the Scandinavian part of the company the Indian engineers are perceived as being used to work by themselves for themselves, not having a group feeling where the strengths of some people can balance out the weaknesses of others. Also the Indian engineers are perceived as being rather indirect in terms of communication and sometimes hiding it, if things are not done for a deadline. Otherwise, the Indian engineers are perceived as being good at theory, very fond of procedures and they generally prefer to be managers as opposed to technical specialists.

4.2.2. Contributions to global innovation performance

The company is experiencing R&D man hour costs as low as €12-€15, compared to €80 in Scandinavia. The Indian engineers perceive the Scandinavian engineers as being somewhat focused on doing more of the same as opposed to come up with totally new innovations. They think that the Scandinavians primarily collaborate within their own specialized groups. Therefore the Indian engineers have established a cross-sectional innovation group in the Indian R&D unit, where ideas are shared. The company is beginning to collaborate with local universities. One radical innovation, which was created in the unit, addresses the well-known fact that the products within the wind turbine industry are growing all the time, thereby increasing the challenges - and cost levels related to logistics. It is very difficult to transport a blade, which is 65 m long and therefore the Indian engineers have come up with a revolutionizing concept, which makes it possible to manufacture the blade in separate parts as opposed to one single mould. The separate parts are then put together at the final location for the wind turbine. This is significantly lowering the costs for the company and it makes it possible to create more profit. The technological challenges related to this breakthrough were primarily of a structural kind, because the stability becomes a problem when the blade is manufactured in separate parts, but finally these problems were solved and top management supports the development and the filing of patents in relation to this new concept, which is implemented for large blades.

The Indian R&D unit have also contributed significantly to the lowering of the new product development time within the company from 24 months to 18 months. The key to this success has been the focus on the development of virtual testing systems.

Also, the Indian engineers have developed new airfoils which enable significantly higher performance than existing solutions. Indian engineers have also improved the manufacturing processes of the company, such that new products can be manufactured much faster and simpler, for instance by applying computer-controlled laser light, in order to improve accuracy and quality. The Indian engineers have also come up with a way to decrease the Styrene emissions from the manufacturing process, which can be considered a very environmentally friendly innovation. The last two innovations has come about as a consequence of an initiative by the company where the Indian engineers meet people from manufacturing in order to talk about, which problems manufacturing people experience, which the Indian engineers can try to solve. Seven patents were filed due to inventions from the Indian R&D unit last year. The Indian R&D unit director emphasizes the positive effect enabling out-of-the-box thinking, which is achieved when R&D activities are transferred to a new environment and new mindsets.

4.3. Med Tech

The company established the R&D unit near Beijing by the end of 2001, among other things in order to get close access to the developing talent base in China. Today the R&D unit employs close to 50 scientists.

4.3.1. Impediments to radical innovation

The Chinese recruits are not used to do applied research. Universities in China are not yet perceived as relevant collaboration partners for the company. Initially, too many people that applied to jobs did not meet the needed standards. This was particularly the case concerning recruitment of people at the middle and senior levels. Concerning how prone the employees are to take initiative, the Chinese scientists in the R&D unit have all the time been good enough to take initiative, but maybe they have feared to do so, because of the management style they are used to in China. The company pushed the Chinese scientists to take initiative too early in the process. They were not ready for it at the time. It is also difficult for the Chinese to cope with the strict project management within the company. Ideas are killed very fast if they are not aligned with the corporate goals.

4.3.2. Contributions to global innovation performance

The company experiences a diminishing cost advantage in China. The main work done in the R&D unit is related to protein purification processes, for instance by the use of bacteria.

The scientists in the Chinese R&D unit have proven their ability to come up with new perspectives on experiments conducted within the company. As one example the R&D unit in China has succeeded in improving a process, which the Scandinavian R&D organization previously conducted as a three-step process: (1) break the protein, (2) filter the protein, and finally (3) chromatography. The productivity was very low and the Chinese scientists tried to find the cause of the low productivity. Their result was that the filtering process decreased the productivity most significantly. A new chromatography was found, which made it possible to skip the filtering process. The overall result was a dramatic productivity increase.

5. Analysis: Europe versus Asia, China versus India

5.1. Impediments to radical innovation

Impediments to radical innovation in China and India			
	Mechanic Tech (China + India)	**Green Tech (India)**	**Med Tech (China)**
Socialization skills	China: Some individual initiative without letting anyone know and without collaborating. Deadlines are exceeded and problems hidden due to lack of interaction.	Lacking group feeling. Lack of individual initiative. Many formal processes. Deadlines are exceeded. Problems hidden due to cultural lack of straightforwardness.	Some individual initiative without letting anyone know and without collaborating. Formal meetings with a lot of irrelevant detail discussion.

Table 1: Impediments to radical innovation in China and India (Source: own).

Mechanic Tech and Green Tech collaborate with universities, however, Med Tech is still not doing much concerning this and it is common for all the case companies that they perceive difficulties in getting new local university graduates up and running in the companies. As outlined in table 1, it seems that a serious problem exists in terms of getting the scientists and engineers to collaborate. In the case of China, the school system seems to put too much pressure on the students. Possibly good technical and theoretical understanding - codification skills, are developed at the expense of training other skills, which are also important for radical innovation, such as the ability to share and develop ideas openly with other people. The focus on the development of individual talents may come with a cost.

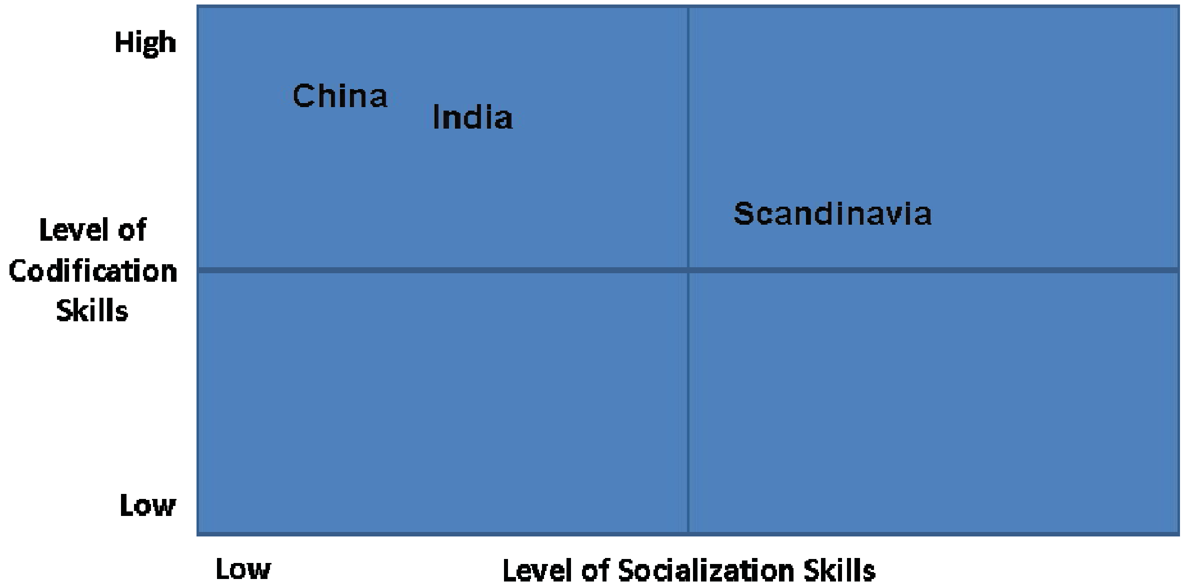

Figure 2: Skill levels of Chinese, Indian and Scandinavian engineers and scientists pertaining to innovation related activities as perceived by the case companies (Source: own).

In figure 2 the skill levels of the Chinese, Indian and Scandinavian engineers and scientists is plotted. Based on the empirical data presented above, there are reasons to believe that the codification skills are actually higher in China and India than they are in Scandinavia, at least concerning certain R&D activities. In India there seems to be collective social initiative, but not so much on an individual level. In the case companies the Chinese engineers and scientists are not taking much social initiative and they have therefore been plotted as having less socialization skills as the Indians. Having some level of codification skills and socialization skills is likely to make it easier to enter the industry as a newly graduated engineer or scientist. The school system in China seems to reward students who are good at internalization. Although internalization is highly instrumental in terms of absorbing already existing knowledge, internalization is only one of several activities needed for knowledge creation to take place. The Chinese and Indian engineers may have good skills in terms of creating and understanding information, which may be tacit for other people, however, tacit knowledge may be difficult for the Chinese and Indian engineers to access.

Country contexts	**Individual initiative**	**Individual socialization initiative**	**Collective socialization initiative**
Scandinavia	X	X	
China	X		
India			X

Table 2: Innovation related individual initiative and socialization initiative across the country contexts (Source: own).

Table 2 outlines differences in terms of taking initiative. By individual initiative is meant something an individual person does, without collaborating with others. Individual social initiative concerns initiatives for activities incorporating other people. An example of collective socialization initiative could be the cross-sectional innovation group in Green Tech, since this is something where the individual engineer does not have to take socialization initiative. In Scandinavia there seems to be individual social initiative, but maybe less collective social initiative across specializations in the R&D department. Individual initiative can enable a person to create tacit knowledge, however, some kind of socialization initiative is needed in order to share this knowledge with others.

5.2. Contributions to global innovation performance

Contributions to global innovation performance in China and India			
	Mechanic Tech (China + India)	**Green Tech (India)**	**Med Tech (China)**
Codification skills	China: Superior India: Very good. Very good training program for new recruits.	Very good	Very good
Socialization	China: Things can be good enough, which is a new R&D worldview in the company.	Cross-sectional collaboration in India as opposed to cross specialization collaboration in Scandinavia. New mindsets.	New perspectives on conducted experiments.
Type of Innovation Activity	Product adaptations to the Asian market.	Process innovation. Product innovations improving performance of products. Virtual test systems speeding up new product development. Product innovations lowering logistics costs.	Process innovation leading to a drastic productivity increase in the protein processes of the company.
Radical Innovations so far?	No	Yes	Yes

Table 3: Contributions to global innovation performance in China and India (Source: own).

In case of the disintegrated blade innovation from Mechanic Tech, the problem was quite evident to anyone in the industry. So this constitutes an example of a radical innovation, which was triggered by in formation or in any case by highly diffused explicit knowledge. Good codification skills may enable engineers to find inspiration for radical innovation in tacit information, which is otherwise not accessible. However, tacit knowledge, e.g. in terms of unarticulated problems, still constitutes a solid foundation for innovation. Green Tech experienced good results when bringing together people from manufacturing and the Indian engineers, whereby the Indian engineers were exposed to relevant problems to solve, which they successfully did, thereby improving the performance of the company.
The disintegrated blade process from Green Tech and the improved protein purification process from Med Tech are radical innovations because they solve problems in new ways, which enable the companies to create a lot of profit. They are also both process oriented innovations. The innovations are not addressing a new problem, instead they are addressing an existing problem or delivering an existing product in an alternative way. Process innovations may not require the same socialization skills as other types of innovations, where both the problem and the solution are new. This may be the reason why the R&D units in

China and India have been able to come up with quite impressive radical innovations as mentioned above in Table 3, in spite of the existing impediments to radical innovation.
Some level of local autonomy, or compliance with the local way of doing things, may be beneficial in order to facilitate radical innovation within foreign invested R&D units in China and India. In China, Mechanic Tech has to a large extent tried to apply the same management style as in Scandinavia, and this has, so far, not resulted in radical innovations. Med Tech has initially made similar experiences, when they tried to force the Chinese to take initiative. Accordingly Med Tech chose to comply with the Chinese preferences. Green Tech has also, to some extent, complied with Indian preferences, however, they run many projects where Scandinavian engineers and Indian engineers work in the same team, and this increases interaction and it helps to decrease the knowledge gap between Scandinavia and India.

6. Implications

6.1. Managerial implications

- The theoretical framework outlined in this paper can inform decisions concerning how to deal with shortcomings in the organization in terms of understanding and creating information and knowledge relevant for radical innovation to take place.
- Complementary R&D skills seem to exist between Europe and Asia. This can be exploited by MNCs, since the Chinese and Indian engineers seem to have very good technical codification skills, which are sometimes superior to European engineers. China is likely to excel in relation to the creation of innovations, which require good codification skills and where the problem solved by the innovation is less socially embedded. Innovations, which can be triggered by information, as opposed to knowledge, and where large benefits can be obtained by applying sophisticated existing technology, to existing problems in new ways, may be a good innovation strategy for China. Such innovations may often be of a process related nature.
- Some level of compliance to Chinese and Indian preferences may be a good idea to implement for foreign companies transferring R&D to these countries. Thereby it may be possible to get a new valuable perspective on the R&D activities of the company.
- Foreign invested R&D in China and India should secure good interaction between the R&D hub of the companies and the new R&D establishments in emerging markets, in order to overcome knowledge gaps. Due to the often good codification skills of new local R&D recruits, information gaps are less likely to exist. Interaction in general nurtures knowledge creation.

6.2. Policy implications

In India and China, large numbers of technically skilled graduates are produced every year. China has more than 1000 Institute for higher education and universities with almost 6,000,000 students enrolled (Chen, 2006). This is something, which is very much envied in the West, where technically skilled talent cannot be found everywhere anymore. For Western MNCs, the talent base, which can be found in China, is an important reason why China is considered an attractive location for R&D (Lewin et al., 2009). However, for China to take back its historical position as a leading country concerning radical innovation some roadblocks need to be cleared. The presented theoretical framework makes it possible to explain more precisely, what the gap between Europe and Asia consists of. Due to the advances of ICT (information and communication technology), information is increasingly accessible on a global scale. To a high extend this also includes technical information, which is often accessible to the public e.g. through patent databases etc. Due to the good codification skills of Chinese and Indian engineers, an information gap does not seem to exist between the West and China nor India. However, knowledge as well as information is important for radical innovation to come about, and some challenges still exist for knowledge creation in China and India. The knowledge gap problem is exacerbated by deficiencies in the educational system, which may put too much pressure on the students, with the purpose of creating individual talents. The availability of individual talents with good codification skills is, however, not enough for radical innovation to take place. It is necessary that the educational systems also provide opportunities for students to develop their knowledge creation potential, by training their abilities to work together with other people on projects, which require self transcending creation - and sharing of ideas. In order for China to step further up the learning curve (Johnson and Weiss, 2008) and innovate in radical ways, it seems relevant to emphasize the development of socialization skills and opportunities for experiential knowledge creation. Whereas technical understanding and skills, gives a person understanding about how problems can potentially be solved, socialization skills may enable access to the knowledge, which is required in order to fully understand problems, which call for radical innovation. Incorporating at the same time superior codification skills and superior social skills in one and the same person, is rarely possible, which is why radical innovations often emanate from the joint activities of groups of people - rather than individual persons. Rather than focusing on the work which students do individually, it may be relevant to put a higher emphasis on group competitions and other things which may incentivize and train the ability to share knowledge, and to understand the knowledge others try to communicate. This may very well take place in the context of Industry University collaborations as outlined by Harryson et al. (2008).

In short, the educational system needs to allow room for failure. A system where only the best are getting opportunities makes it risky for students to take chances and to experiment. Many innovations have come about as a result of mistakes. It is difficult to train the ability to “fail in order to succeed” (Baxter, 1995), if you are not first allowed to fail.

6.3. Implications for further research

- In all the case companies it is perceived as a problem that the Chinese and Indian engineers and scientists do not have a strong propensity to take individual social initiative in relation to their work. The cross-sectional innovation group in Green Tech seems to offer a viable solution to this problem, however, the question remains if such initiatives inhibit individual socialization initiative, which in the long run might create better results? Further research might attempt to answer this question.
- As the country and the legal system develops, it is likely that the Chinese will start to trust weak ties more, and maybe they will also develop more of them, in spite of their claimed preference for few and strong ties (Boisot and Child, 1999). This may have a positive impact on radical innovation in the country, but the answer to this question is left for further research, which may find inspiration in existing research concerning institutions and networks (Jansson et al., 1995, Jansson, 2006, Jansson et al., 2007).
- Process innovation seems to be the common denominator of the radical innovations presented in this case study. Harryson et al. (2008) hypothesized that process oriented industries are less dependent on proximity and to some extent their hypothesis is supported by the research presented in this paper, since the innovations presented in this paper take place in R&D organizations, which are global. Further research may improve our understanding of this subject.

- Further research might also look at relationships between codification skills, socialization skills and absorptive capacity (Cohen and Levinthal, 1990) of organizations.

7. Conclusions

Addressing a deficiency with existing theory, this paper provides a new distinction between information and knowledge, which embraces the often tacit nature of complex explicit knowledge - or tacit information. The developed framework, built on knowledge creation, innovation and network theory, was illustrated and validated through three cases of foreign invested R&D establishments in China and India. The cases show that impediments for radical innovation exist in both China and India. Innovative efforts, which can be triggered by information, as opposed to tacit knowledge, may be more likely to come about in China due to the existing knowledge gap. While this knowledge gap, and other serious impediments for knowledge creation may inhibit radical innovation, policies and practices outlined in the last parts of the paper, can be implemented to secure a better environment for radical innovation in China.

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