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Management and Organisation of Knowledge Creation in Emerging Markets: a Perspective from subsidiaries of EU MNEs

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Summary

A key emerging trend in the globalization of innovation is that an increasing share of R&D is being undertaken in Emerging Markets, especially in India and China. This paper focuses on the involvement EU MNEs in this process. It is based on 22 interviews conducted with managers of R&D centres of 15 EU-based companies located in India and China. These companies are amongst the leading R&D spenders in 3 industries: ICT, Automobiles and Pharmaceuticals.

In terms of activities, the centres (especially in the ICT and Automotive sectors) do not cater for local demand but contribute to the parent company's global product development by both developing new products and solutions and improving existing ones. They mainly respond to project and product development requests from various business units of the parent company. Over time demand considerations are becoming more important for some of the companies reflecting the importance of a large and growing market in India and China. Another important finding in relation to evolution of the centres is that many of the centres were initially set up to undertake routine (non-strategic) support functions for saving costs. However, they have gradually undertaken more advanced and complex tasks as their capabilities have evolved over time. Thus centres that have been present in India over a long period have evolved into taking complete responsibility for global projects. Such projects are now managed by global R&D mangers in India with company employees from other locations reporting to the Indian centre.

The main strategic driver for location in India and China is the availability of a large pool of well-qualified scientists and engineers. However, over time market related factors have also become important. Thus there is some evidence that the EU companies are developing low cost products specifically for the local markets both by adapting products introduced elsewhere and by developing completely new products. For example the EU Pharmaceuticals companies are involved in the development of new drugs for the diseases that are prevalent in India and China such as TB. Some of the Auto R&D centres are catering for the demand for low cost products and technologies, by localising existing products and technologies, which involves re-engineering and implementing cheaper solutions.

Most of the R&D centres in the study have some collaborative activities with local institutions. They regard such cooperation with other firms, universities and research institutes as an important means to access the complementary technology and resources. For example most of the centres in ICT and Pharmaceuticals have some collaboration with local universities and research institutes. There are some differences in the underlying motives in the two sectors. For example in the ICT sector one of the reasons

for linking with universities is to recruit skilled post-graduates. In the case of Phramaceuticals the emphasis is more on connecting with developments in basic research. For the Automotive companies, the local linkages are more with suppliers (in the case of Auto manufacturers) and customers (in the case of Auto suppliers).

In general the centres of EU MNCs in India and China enjoy a great deal of local autonomy. More specifically there is greater autonomy in operational and day to day running of the centres, but some of the strategic functions are steered centrally. Thus the hiring and firing of technical as well as non-technical personnel are at the discretion of the centre as is the day-to day management of the centre. However, strategic decisions such as budgeting, capital expenditures, decisions on patents and trademarks are undertaken at the centre.

The most important managerial challenge faced by the centres relates to human resource management. This is not surprising as the availability of large pool of well qualified scientists and engineers is one of the important driving forces in R&D off-shoring decisions of EU MNEs. However, the recruitment of a large number of suitable candidates is not easy in India and China due to the wide disparity observed in the quality of the technologist and engineers available. Even more of a challenge is the recruitment of experienced mangers for more important roles.

1. Background and Aims

The main objective of this paper is to provide insights into off-shoring of R&D and other innovative activities of EU MNEs. The recent surge in interests in the phenomena can be attributed to a number of trends. The first is that many new products and processes require knowledge inputs from multiple fields, not all of which may be available in a single location. The second is that in many industries compressed product life cycles mean increased speed to market and simultaneous introduction of products in all major world regions. This inevitably requires some technology creation in different regions. Third is the emergence of countries such as India and China which combine enormous market potential with a large pool of well-qualified scientists and engineers. It is the implications of this last trend that is the focus of this paper.

By focussing on the R&D centres of the EU MNEs in the emerging markets of India and China, this paper draws attention to the kind of activities that are undertaken in these centres, their role within the overall R&D structure of the company, and to highlight any distinctive features in the agenda and functioning of the R&D centres in the three sectors. Further, the paper focuses on the relation between the competence of the R&D centre, the delegation of autonomy, its market orientation and how well it is globally integrated. A dynamic element is introduced by tracing the evolution and changes in the strategic focus of the R&D centre over time. By comparing R&D centres of each company in India and in China the aim is to advance our understanding of the most important factors underlying MNEs' internationalisation strategies.

This paper focuses on the in knowledge creating activities of EU companies in Emerging Markets. It is based on 22 interviews conducted with managers of R&D centres of 15 EU-based companies located in India and China. These companies are amongst the leading R&D spenders in 3 industries: ICT, Automobiles and Pharmaceuticals. The paper is structured as follows. In Section 2 we discuss the methodology. Section 3 presents an analysis of the material collected in the interviews. We begin by focussing on the agenda and activities of the R&D centres as well as their evolution over time, by exploring their history and growth and the characteristics of the centre at inception. The analysis also deals with the perceived importance of various strategic factors that have driven the decision to set up the centre. Further we focus on the management of the R&D centres,

their cooperation strategies and their integration into the global innovation networks. In Section 4 we summarize the main results and present some conclusions

2. Methodology

The selection of the EU MNEs was based on the fact that they were amongst the leading players in their respective industries both in terms of market share and in terms of being large employers in their home countries. They are also amongst the leading R&D spenders in the EU. Another criterion for selection was whether the company had established R&D and innovation activities in the India and China.

The data gathering was facilitated by means of semi-structured interviews undertaken at the R&D centres of the EU MNEs in India and China. The person interviewed was the head of R&D. A four page structured questionnaire comprising 23 questions was used as an interview guideline. There are 4 sections in the questionnaire, the first of which captures information about the R&D in the company as a whole. The second and third sections are devoted to the activities of the R&D Centre. The centre's structure and relationship with HQ and other R&D centres of the company are captured in the final section. The instrument was constructed in such a way that the template for interview guidelines used at the Indian subsidiary could be used for interviews in China with only minor modifications.

This original aim of the exercise was to provide comparable data on each of 15 MNEs on their R&D activities in India and China across the 3 sectors: ICT, Pharmaceuticals and Automobiles. However, in certain case it was not possible to interview the R&D Centre Head in both the countries. For example this is the case for Infineon and ST Microelectronics, where only the R&D centre in India was interviewed. Similarly, for two of the Pharmaceutical companies, Sanofi Aventis and NovoNordisk, the interviews were only conducted in one country. In the case of Auto MNEs, it was difficult to secure interviews with R&D Heads in both India and China due to the crisis in the industry. Table 1 lists the companies interviewed.

Table 1. List of the MNEs Interviewed

	India	*China*
ICT		
NSN	y	y
Philips	y	y
Ericsson	y	y
Alcatel	y	y
Infineon	y	n
ST Micro	y	n
Pharmaceuticals		
AZ	y	y
GSK	y	y
Sanofi Aventis	y	n
NovoNordisk	n	y
Automobile and Parts		
Volvo	y	n
Bosch	y	n
Continental	y	y
Centre X	n	y
Autoliv	n	y

3. R&D Centres of EU MNEs in India and China.

3.1 Agenda, Activities and Capabilities

In general there is a lack of consensus in the literature with respect to the kind of R&D activities that the firms internationalise in emerging countries. One view is that innovation activities in foreign R&D centres are only concerned with local product adaptation through intensive cooperation with customers and suppliers. Previous empirical evidence has suggested that a large part of MNEs' R&D activities in China are market driven and development oriented rather than research oriented. For example two-thirds of MNE's R&D alliances in China between 1995 and 2000 are development oriented (*Li and Zhong 2003*). Further a recent study has argued that the likelihood of establishing a local development unit increases if a given firm's business requires local product adaptation and intensive customer cooperation (*von Zedtwitz and Gassmann, 2002*). Another view is that innovation activity of MNE's can best be described as global generation of innovations, i.e.,

innovations are conceived on a global scale from the moment of inception in an interplay between R&D and innovative activities both in the home and the host countries (*Archibugi and Iammarino 2002*). This is partially supported by cases of US companies like Cisco and Intel. Cisco's second global headquarters is setup in Bangalore to leverage India's engineering resources and develop products for Indian and other emerging economy markets. In the case of Intel, product development accounts for 65% of Intel's India activities today and has recently begun designing products in India aimed at developing country markets.

The aim here is to provide further our understanding of the type of activities undertaken by EU MNEs in emerging countries. One issue discussed here is whether such companies undertake innovation activities around their core technologies or are engaged in more peripheral activities. Further we assess the R&D undertaken in India and in China is aimed at local or global markets by analysing the nature of the tasks undertaken and their market orientation. We show that the role played by the centre and the kind of tasks undertaken are dependent on both the technical and managerial capabilities of the centre and its strategic importance to the MNE's global R&D strategy. The host region's supply factors such as the local technical/scientific skills and the competence of the supplier base have an influence on this. The relevance of market factors such as the local demand for low cost products and the flexibility in operations to meet those demands are also important as are the internal demands from various business units within the organisation. Table 2 contains information on the agenda and activities of the 22 R&D centres surveyed in our study. We begin the discussion by focusing on the types of activities undertaken by the centres by grouping them according to industry.

ICT firms

The evidence for the 10 R&D centres in the ICT sector located in India and China shows they are essentially development centres involved in functions such as software development, design (hardware design and software design) and engineering. The software related centres, mainly located in India, undertake specialised functions and serve the project and product development requests from the parent company's various business units (BU) and are funded by these units. The search for global efficiency has driven the concentration of these specialised functions to a single location thereby

reducing duplication. Thus these centres do not cater for local demand but contribute to the parent company's global product development by both developing new products and solutions and by maintaining and improving existing ones. The main reason for choosing India as a location is the availability of a large pool of software engineers, developers and testers.

Table 2 Agenda and Activities of the R&D centres

	Centre Funded By	*Year of Set up*	*Nature of Task*	
			Research	*Development*
ICT India				
1. NSN	BU	1994	-	100%
2. Philips	BU	1996	10%	90%
3. Ericsson	BU	2006	5%	95%
4. Alcatel	BU	1995	Under 5%	Above 95%
5. Infineon	BU	1997	-	100%
6. ST Micro	BU	1995	Under 5%	Above 95%
ICT China				
7. NSN	HQ	2007	1%	99%
8. Phillips	HQ>50%, BU < 50%	2000	60%	40%
9. Ericsson	HQ	1999	5%	95%
10 Alcatel	-	2002	-	100%
Pharma India				
11. AZ	HQ	1984	100%	-
12. GSK	HQ	2004	-	100%
13. Sanofi Aventis	HQ 85%, BU 15%	2004	-	100%
Pharma China				
14. AZ	HQ	2007	50%	50%
15. NovoNordisk	HQ	2002	50%	50%
16. GSK	HQ	2007	50%	50%
Auto India				
17. Volvo	HQ	1998	-	100%
18. Bosch	R&D centre	1992	-	100%
19. Continental	BU	2007	-	100%
Auto China				
20. Centre X	BU	1985	5%	95%
21. Continental	BU	2006	10%	90%
22. Autoliv	HQ	2009	-	100%

The design centres are mainly concentrated in China and are engaged in the design of hardware and to some extent the design of software as well. For most of these centres developing specific features for the local market constitutes only a minor part (Ericsson China centre is an exception). Again the main strategic drivers for their locations are availability of skills and cost savings rather than market related factors.

These finding confirms past research which has suggested that MNEs are especially attracted to host countries that have the combination of low wages and large pools of skilled workers (*UNCTAD, 2005*). They are also consistent with the evidence from the Indian R&D centres of US ICT firms that almost 65% of their total R&D investment is focused on software development and 16% on hardware and product development (*Mrinalini, 2009*).

There are some signs that for some of the companies demand considerations are becoming more important over time reflecting the prospects of large and growing markets. This is the case for Ericsson China, where the localisation of existing products and technologies to meet the demands for emerging countries has been high on the agenda. Almost all (90%) of its operations in China are to cater for local specific requirements that are very different from those of the markets in the developed countries.

Our evidence also shows that localisation needs are different in India and China. For example Alcatel undertakes extensive localisation at their R&D centre in China but not in India. According to ALU:

'*India is still not a major customer for ALU, in comparison to China. Installations in India are 2G. There are teams that support the legacy installations (such as the E10 switches). Focus on India is on voice, the 3G licenses have not been given out by the Government, whereas, China is already 4G and by virtue of being a major customer also has a much bigger R&D.*'

In 7 out of 10 ICT centres there is some evidence of research being undertaken in collaboration with local universities, but this constitutes a small part of the activity of most centres. This suggests that the role of some of these development centres is to act as listening posts monitoring the science and technology developments in these emerging markets (*Cantwell 1995; Dunning and Narula 1995*). The only exception is Phillips centre in China, where the research projects exceeds the development projects.

Automobiles firms

The 6 R&D centres interviewed in India and China belong to EU auto manufacturers and auto component suppliers. With respect to the auto component suppliers in India (Bosch and Continental), the centres are exclusively involved in providing support for product

development at the various business units of the company. This takes the form of either software development in the case of Continental or the provision of engineering services related to both hardware and software in the case of Bosch.

Other centres are involved in simultaneously developing products for the emerging markets and undertaking specialised functions for the company as a whole. This is the case for the Volvo centre in India which is developing products for the emerging markets as the same time as providing specialised software and engineering functions for other business areas of the company.

In a number of cases R&D centres are mainly catering for the demand for low cost products and technologies, by undertaking localisation of existing products and technologies involving re-engineering, cheaper design implementations and other adaptations. This is the case for Autoliv in China which mainly develops products for the Chinese market by improving already existing products. The main role of these centres is in identifying specific local requirements that require new innovations. If such innovations are significant, they are made standard for all their products. For example the Autoliv facility in India plays a critical role in the company's overall effort to improve safety for small cars.

A further factor in the decision of the 2 Auto component suppliers (Autoliv and Continental) to establish R&D centres in China was to have a presence in one of the largest automotive markets in the world, close to the growing R&D presence of major international car manufacturers in that location. The rationale was that the differential local unique demands on products, such as smaller engine for smaller cars, could not easily be met by the high specification products used in high-end cars that are available for the EU market. Further these two companies were also responding to demands from the local OEMs for rapid solutions to the problems encountered in production engineering.

Pharmaceutical Firms

The 6 R&D centres of Pharmaceuticals companies in our study are either clinical development centres or are developing drugs with a specific therapeutic focus. In the case of drug development these companies view India and China as important markets and consider it essential to develop medicines for this market locally for two reasons. Firstly, for the diseases that are prevalent in these markets it is essential that the R&D is undertaken

locally. As an example the AstraZeneca (AZ) India centre has been undertaking research on tuberculoses since 1984. Similarly NovoNordisk in China undertakes the development of drugs for the large and growing market of diabetes in that country. The second reason for locating in India and China is the realization by MNEs that development of low cost drugs is vital in order to succeed in these markets. For AZ China, 70% of its activity is centred on improving existing products to cater for the Chinese market, but in near future it aims to develop new products that are tailored to Chinese market.

In China there is evidence that centres are undertaking significant amount of research, but as these centres were established very recently and are often small-scale facilities they are still in very early stages of drug discovery. For example at GSK the focus is on research in neuroscience and the centre is at the early stages of the discovery process for two neural compounds. In the case of AstraZeneca, the China centre focuses on translational science and has not yet developed any new products. It was established in 2007 with less than 5 people and the R&D executives are mostly ethnic Chinese who worked in USA or other countries for over 10 to 20 years. This means that the cost-savings achieved by locating in China are limited as the expatriate employees are usually earning salaries that are similar to their counterparts in the US or Europe. A similar strategy of employing ex-pat Chinese scientists is undertaken by the Novo Nordisk R&D Centre in China.

Another key reason for Pharmaceutical companies locating is in India and China is to undertake clinical development by establishing linkages with the local Contract Research Organizations (CRO). These companies are involved in in-licensing with service providers and are out-sourcing some routine work to nearby CROs. In the case of India this is due to the strong heritage in the production of generic drugs and the highly advanced skills base in Chemistry. For example GSK outsourcers work requiring such expertise (e.g. toxicology work) to different contract labs, many of which are in Hyderabad, Bangalore and Shanghai. In India, the Sanofi Aventis centre is involved in clinical development catering for the various requests from within the company.

Summary

Majority of the 22 Centres in our sample declare that the development of new products and processes for the global market is their main goal. An analysis of the types of activities undertaken by them shows that they perform specific functions such as software

development, development of hardware component or design and implementation, and clinical development. These activities contribute to the overall development of core products and technologies undertaken at the HQ/corporate laboratories (or at other global development centres). In general adaptation of products for the local markets or the development of entirely new products for those markets is a minor part of their activity. Finally some part of their function is to act as listening posts for the company as a whole.

3. 2 Evolution of the R&D Centres

The literature on internationalisation of R&D amongst MNEs shows that the process followed is often sequential and is strategically driven in order to take advantage of the global efficiencies and capabilities (*Johanson and Vahlne, 1977*). The main idea being that often a centre is initially set up in a location for a number of varying reasons such as adapting a product or taking advantage of a specific set of skills or lower costs. However over time as the centre becomes more mature and the capabilities of management and staff evolve its functions evolve. This is the case in a number of the centres in our study. For example the strategic decision to set up an R&D facility in India and China was driven largely by the cost factor and in some cases by supply and market factors. Thus initially there was a delegation of low-end, routine and non-core tasks to capitalise on the low-cost advantages and the availability of large pool of quality skills. As the work force became more experienced, further work packages and complex tasks requiring specific higher order skills and experience were added, resulting in a greater role in overall product development of the parent company.

An example of this process is provided by the Indian ICT centres in our study. These centres that have been present in India over a long period have evolved into taking complete responsibility for global projects. Such projects are now managed by global R&D mangers in India with people from various other locations reporting to the Indian centre. Thus the Infineon design centre in Bangalore was set up in 1997 as essentially a resource augmentation centre. Over the years it has consolidated its position in the company by acquiring greater knowledge and getting more involved in the product roadmap and project management. More recently, the centre has advanced further by assuming complete product development responsibilities, involving the management of global teams. Similarly, STMicroelectronics set up a design centre in 1995 which initially undertook

characterization, design layout, work on libraries etc. As the workforce became more experienced, the centre has advanced to designing full chips and complete systems (set top boxes). As a consequence 15% of also VLSI design and software activities at STMicroelectronics are carried out in India in 2007, making it the largest design centre outside Europe contributing to one of the company's lead technologies. For the parent company the initial attraction of India was an abundance of engineering skills. Further the centre enabled flexibility of operations allowing the company to upscale and downscale as desired, thus contributing to its rapid growth.

This process is also evidenced in the case of a number of Auto R&D centres. For example when the Bosch centre in India was setup it only undertook embedded software development but it gradually moved up the value chain so that today its activities encompass complete product design i.e., electronic design, hardware design, software design and integration. Additionally, when the centres were set up the Indian market was of little importance to Auto component suppliers, but recently supplying the Indian OEMs has increased in importance. Hence in Continental certain business units have started partnering with Indian auto companies. The Volvo India centre has gradually evolved from a strategy based on local supplier sourcing and purchasing to developing products for the emerging markets. At the same time its engineering outsourcing activities was the initial priority while setting up the centre. Over the years, it has led to the centre being involved in specialised functions serving the various business areas at Volvo.

Size and Age

Table 3 shows that there is a great deal of variety across sectors and locations in the age of the R&D centres in our study. In general the centres in ICT and Automobiles are older: 7 out of 10 in the former and 3 out of 5 in the latter are more than 10 years old. In contrast 5 out of the 6 centres in Pharmaceuticals have been in existence for less than 10 years. Additionally majority of the Indian centres have been established over a long period compared to those in China. For example 8 of the 12 centres in India were created more than 10 years ago compared to 3 out of the 9 in China.

Table 3 Age and Size of the R&D centres

	No. of R&D personnel employed currently	Year of set up	Years since set up	Size at Set up
ICT				
1 NSN India	2400	1994	16	250
2 NSN China	3000	2007	3	Under 500
3 Phillips India	750	1996	14	Under 100
4 Phillips China	200	2000	10	20
5 Ericsson India	400	2006	4	80
6 Ericsson China	3000	1999	11	10
7 Alcatel India	2600	1995	15	50
8 Alcatel China	above 1000	2002	8	40
9 ST Micro India	2200	1995	15	40-50
10 Infineon India	650	1997	13	Under 50
Pharma				
11 Astreneca India	110	1984	26	15
12 Astreneca China	70	2007	3	Under 5
13 NovoNor China	80	2002	8	10
14 GSK China	300	2007	3	68
15 GSK India	75	2004	6	8
16 Sanofi India	above 600	2004	6	handful
Auto				
17 VW China	5700	1985	25	70 to 80
18 Bosch India	500	1992	18	63
19 Volvo India	500	1998	12	20
20 Continent India	500	2007	3	Not available
21 Autoliv China	Not available	2009	1	-

3.4 Drivers for Establishing R&D Centres in India and China

There is a great deal of consensus amongst the centres in terms of the critical factors in setting up R&D centres in both India and China. The main driving force regardless of location is the quest for scientific and technological talent. Thus the R&D managers rate the availability of a large pool of qualified human capital as the most important factor in setting up the R&D centre. The lowering of the cost of R&D is also important. However in the case of the other factors such as prospects of a large and growing market and proximity to the customers there are major differences between the Indian and the Chinese centres. Part of the reason for this discrepancy could be the different sectoral mix in the two locations but this appears not be the case as seen in Table 5.

Table 4 Important Factors for setting up the R&D centre

Mean Score (Likert scale1-5)	**China**	**India**
Availability of a large pool of qualified human capital.	4.44	4.45
Lowering the cost of R&D	3.89	4.18
Prospect of a large and growing market	4.33	2.17
Proximity to customers	4.22	1.92
Quality of protection of intellectual property	3.22	2.42
Direct government assistance for the location of R&D	3.22	2.42
Availability of good infrastructure	3.00	2.42
Proximity to suppliers	3.33	1.58
Gaining knowledge about competitors	3.44	1.20
The establishment of an R&D facility was a regulatory or legal prerequisite for access to the local market	2.67	1.00

Table 5 Important Factors for setting up the R&D centre in China and India

	ICT		***Pharma***		***Auto***	
Mean Score (Likert scale1-5)	***China***	***India***	***China***	***India***	***China***	***India***
Availability of a large pool of qualified human capital	4.8	4.3	4.3	5.0	4.0	4.0
Lowering the cost of R&D	4.3	4.0	3.3	4.0	4.0	5.0
Prospect of a large and growing market	4.0	2.0	5.0	3.0	4.5	1.7
Proximity to customers	4.0	1.2	4.3	3.7	4.5	1.7
Quality of protection of intellectual property	3.8	2.8	2.7	2.3	3.0	1.7
Direct govt. assistance for the location of R&D	3.8	3.2	2.7	1.0	3.0	2.3
Availability of good infrastructure	3.3	2.8	3.0	3.0	3.0	1.0
Proximity to suppliers	3.8	1.2	2.3	1.0	4.0	3.0
Gaining knowledge about competitors	4.0	1.0	2.7	1.0	3.5	1.3
The establishment of an R&D facility was a Regulatory/legal prerequisite for access to local market	3.0	1.0	1.0	1.0	4.0	1.0

Our evidence from the 9 Chinese R&D centres indicates that internationalisation of R&D of EU MNEs is orientated towards demand-pull strategies and customer-focused initiatives. The prospect of a large and growing market in was an important driver for these companies in China, as important as the availability of large pool of qualified human capital. Similarly, proximity to customers is another key factor for setting up in China. This implies requirement for localisation of products and process, and for R&D capability to ensure greater and faster responsiveness to local market conditions and to support the existing manufacturing operations in China.

While market-side factors were not important in setting up the R&D centres in India, the

managers indicated that they have become more important over time. On the other hand, the availability of qualified human capital in abundance in India is the most important followed by low- cost advantages. This seem to indicate that the functions in India are more supporting functions, where, capitalising on cheaper labour arbitrage leading to greater functional efficiency and cost saving. Escalating cost in conducting R&D in Europe has led firms to turn to these new locations to scout for the scarce talent and resources.

3.5 R&D co-operation, Relationship with HQ & level of Autonomy

R&D co-operation

Most of the surveyed R&D centres regardless of sector or country have some collaborative activities with local institutions. They regard such cooperation with other firms, universities and research institutes as an important means to access the complementary technology and resources. For example in the ICT sector ST Microlelectronics centre in India has dedicated laboratories at premier research institutes in India such as IISc Bangalore, IIT Delhi and BITs Pilani. The Alcatel facility in China collaborates with some universities and major telecoms operators such China Telecom and China Mobile. Ericsson centre in China co-operates with Beijing University of Posts and Telecommunications, Tsinghua University, Southeast University in Nanjing. Such collaborations involve sponsoring of research projects at the universities that are undertaken for Ericsson. In the case of the Ericsson centre in India the main purpose of the university collaboration is to source talent. At any point in time, about 20 interns (mostly post graduate students) working in the company and are eventually absorbed.

The evidence from the Auto sector also shows that local linkages are important. In the case of Continental, the centre in India was relatively recently established (in 2007) and has already developed the linkages. Its collaboration in India is mainly with suppliers who are considered as dedicated partners for software services. The centre is also providing consultancy services to local auto manufacturers such as Mahindra, Tata and Elexi Altran. Auto Centre X in China was set up in 1985 and has research cooperation with universities, research institutes, and even some competitors mainly dealing with research projects on auto parts.

More long term and extensive research collaborations with universities, research institutes and small bio-companies are evident in the case of Pharma R&D centres. This is not surprising as research projects forms the core of their activities. In the case of AstraZeneca the centre in India has research links with the India Institute of Science. In GSK and Sanofi-Aventis, the collaboration is with local contract research organisation as clinical trials are the most important functions at their facilities in India. In the case of Sanofi Aventis, research collaboration effort is just getting started. According to the R&D head, '*Pharma companies have realized that in-house drug discovery doesn't scale. Most of the pre-discovery happens in academic institutions. These are picked up by Pharma companies and taken through the development process. Externalization is a major focus for Sanofi Aventis. The company is looking at partnering with several CROs and universities to build a strong pipeline of new molecules. Sanofi-Aventis is keen on partnering with institutions such as Central Drug Research Institute*.'

Evidence of greater local research alliances are a feature of the pharma centres in China. AZ centre in China with strengths in translational science has alliances with local academic institutions such as Beijing Medical School on basic science, and has established technical collaborations by investing in local bio-companies. For clinical trials AZ has long-term collaboration in Shanghai, Guangzhou and Beijing. NovoNordisk has a research foundation with Chinese Academy of Sciences with an endowment of $2million to undertake research in diabetes, bio pharmaceuticals and protein sciences. Links with customers, suppliers, consultancies, and research institutes are also evident.

Together with these local linkages there is evidence from our R&D centres that they are also a part of the global innovation network. The case of NSN centres in India and China, shows some interesting contrasts in this respect. The NSN centre in India, though it was established in 1994, it is not as big as the centre in China (set up in 2007). The Indian centre has dense global network and has also achieved strong local links. It has ongoing internal collaborations with other business units within the company, and externally with suppliers, and customers in Asia, Europe and other parts of the world. The local links are evident from its collaborations with suppliers, customers, consultancies and universities in India. But in the NSN centre in China, the local links with customers are non-existent and the university collaborations have only just taken off. Similarly Bosch which established the R&D centre in India in 1992 has strong research linkages with other business units

within the company, suppliers, customers, and competitors in worldwide locations.

Relationship with HQ and level of Autonomy

The MNEs with globally dispersed R&D are mainly dealing with the dual task of increasing the local responsiveness on the one hand and on the other hand to achieve effective global integration of their R&D (*Bartlett & Ghoshal, 1989; Luo, 2001*). The level of autonomy delegated to the local centre mainly reflects the company's way of balancing these dual tasks and depends on a number of factors such as strategic alignment of goals and objectives, human capital management and to achieve operational efficiency.

The R&D managers were asked about the overall autonomy delegated to the centre by the HQ and also the autonomy granted in individual tasks. The results are reported in Table 6. They show that there is considerable autonomy granted to the centres in our study. There are some small differences across sectors. For example Pharma centres display a slightly greater overall autonomy compared to the Auto and ICT sectors.

On comparing the level of autonomy in 9 different functions across the three sectors, the general trend observed is one where there is greater autonomy in operational and day to day running of the centre, and the strategic functions are seen to be centrally steered. Thus the hiring and firing of technical as well as non-technical personnel are at the discretion of the centre. So is the day-to day management of the centres. However, strategic decisions such as budgeting, capital expenditures, decisions on patents and trademarks etc. happen at the HQ and are handed down to the individual R&D centres.

It is interesting to note that there is fairly high autonomy in the decisions on the external collaborations in all cases. They are managed and decided by the centre without much involvement of the HQ. This is essential as there are many advantages resulting from the centre's greater embeddeness locally, and external collaboration is key to this.

Table 6. Autonomy Delegated in the Functions by HQ to the R&D centres

Mean Score	*ICT*	*Pharma*	*Auto*
Overall Autonomy of the R&D centre	3.4	4.3	3.6
Individual Tasks			
Hiring and firing non technical personnel	4.9	4.8	4.6
Hiring and firing technical personnel	4.9	4.8	4.4
Day-to-day management	4.5	4.8	4.8
Hiring and firing of senior managers	3.8	4.5	3.5
Cost control	4.2	3.7	4.8
Patents and trademarks	2.7	2.8	3.8
Financing	2.2	3.7	3.8
Deciding capital expenditures	3.2	3.8	3.3
Collaboration with external partners	3.8	4.2	4.3

The level of autonomy may be restricted due to the multi-level and multi tasked nature of the projects. The activities of the R&D centres are often a part of global projects spanning world-wide locations and hence are centrally coordinated. Thus the level of autonomy delegated to the dispersed R&D centres is not so much dependent on whether the nature of activities involves product development, research, or just supporting and maintenance roles, but rather more on the fact whether projects need to be integrated into the system or can be stand alone projects and tasks that calls for less central coordination. This is highlighted by comparing the R&D centres within each sector.

In the case of Philips, the company works in a global collaborative environment of Innovation Centres and Businesses, and is organised such that the activities of R&D centre in India and its outputs are integrated into the system. The strategic direction of the business at Philips is set by the Business team and the R&D centre in India contributes in the roadmap and project delivery. According to the R&D centre head in India '*we manage the projects independently but in close collaboration with other teams, as our solutions are to be integrated in the system and must delight our customers'*. In ST Microelectronics and NSN, their India centre is part of a global R&D setup and the decisions are taken based on consensus between the centre and HQ.

The Sanofi-Aventis and GSK centres in India are involved to a large extent on clinical trials and these are centrally coordinated and a follow a common protocol across the world to ensure quality. According to Sanofi Aventis, '*Centre has complete autonomy in operational issues. This includes choice of doctors to work with for clinical trials,*

dealing with India specific issues etc. But otherwise, clinical trials have very little elbow room'. At the other end of the spectrum for the NovoNordisk China center research tasks are a large part of the projects undertaken and many of these R&D projects are world wide and require approval from the HQ's management team.

In other instances, the strategic importance of the flexibility in responding to the market determines the higher autonomy in operational issues delegated to the R&D facility. At AZ, in their Chinese centre where research makes up half of its activity, there is greater autonomy in operational issues. The greater operational independence is bestowed upon mainly because China is considered as a target market, and in order to respond to the local growth, the R&D center is given high autonomy on decision making and manpower recruiting.

Within the same centre the level of autonomy depends on the specific function being undertaken and the competence of the group involved. As an example the Infineon R&D centre in India undertakes embedded software development for three Business divisions: Automotive, Wireless and Industrial. Wireless software development makes up more than 80%.of the centre's activity and some new products for the Indian market are essentially driven by this division. However, in spite of being a small part of the centre's activity, the Automotive division commands very high autonomy compared to the other two functions. This mainly a function of the centre's strong capabilities in the specialised automotive software development.

In the case of Bosch, the R&D centre in India provides engineering services to all Bosch divisions. This R&D centre, subject to corporate governance guidelines, enjoys a high level of autonomy, being an independent legal entity in India. However, limited autonomy is observed in other cases where, only technology localisation is the agenda of the R&D centre: for example at Auto centre X in China.

Performance Evaluation Mechanisms at R&D Centre

There are a number of mechanisms for evaluating performance in place at the R&D centres included in our study. Such evaluations are designed to engage staff, motivate them and to strategically align the goals of the centre to overall company strategy, and involve a number of formal and informal mechanisms. For example in the Sanofi Aventis

centre in India the speed, quality and cost are measured using Clinical Trial Management Systems (CTMS). At the GSK India centre in addition to the formal indicators such as the volume of patient recruitment and quality of data generated, the evaluation also focuses on recruiting well trained technical staff and retaining them. At the AstraZeneca (AZ) China facility, two measures are devised. The first is the 'Research portfolio', whereby scientific teams closely review their progress and outcome. This strategy serves to promote scientist's entrepreneurial culture and to cut the team's budgets if the team does not show anticipated deliverables. The second measure is the 'Focus of research' where each team's output is evaluated and if the research direction has deviated from 'translational science' the project is terminated. In AZ India the number of new molecules developed is a performance criterion and the centre's goal is to develop a new molecule every 18-24 months. At the Novo Nordisk China, producing sufficient quantity of protein analogues is the measure used. When this centre takes part in new drug R&D projects at the global level each project has some time-phased and measurable targets.

In the case of the Auto centres a number of different evaluation mechanisms are in place. The Continental facility in China for example uses market share, order intakes and internal scorecards. The formalised measures to evaluate achievements include Q gates and metrics and project financial situation. Thus scorecards are devised to measure finance, process adherence, number of innovation ideas, defect density (number of problems per project), fluctuation etc. At the Volvo India centre, size of the work package and efficiency based on hourly rates are the two mechanisms used. ST Microelectronics uses the quality and robustness of the products designed from the India centre at the customer site as the main performance criteria. Innovative new features that go into the products designed are also a measure of the centre's success.

An interesting observation is that the number of evaluation criteria varies widely across companies in the same industry and in the same location. This can be illustrated in the case for ICT companies. For example Ericsson China uses cost, timely completion of the project, quality and satisfaction of staff. On the other hand the number of technologies being transferred and standardizations are two formal measures employed for evaluation at the Alcatel China centre. With regards to innovation, both Alcatel and Ericsson use the number of patents and publications. However the number of new-product ideas is also an important evaluation criterion at Ericsson. In Philips evaluating performance occurs at

both individual level and at centre level. Some of the indicators used are common at both levels such as the number of patent filings and technical reports. However, the most important indicator to evaluate its Chinese R&D centre performance is technology commercialization as proxied by the revenue contribution from new technology. At the NSN centre in China the cost of product development is used for evaluation in order to enable the comparison across different product lines and across different R&D centres. Other measures involve the time to market of product commercialization, production costs related to R&D design such as material cost, the complication of manufacturing, modulation design, etc. and the employee turnover rate.

Challenges in the Efficient Management of the Centre

The various challenges faced by the R&D centres in our study are quite specific to each sector and the seriousness of these inhibiting factors also differs across India and China. For example, it is interesting to note that the problems arising as a result of cultural differences do not seem to be a major challenging factor in Pharma or ICT (see Table7). But this is relatively more of a challenge in the Auto MNEs in both India and China. This could be due to the fact that Auto centres are involved in greater localisation of products and technologies, which involves interacting with local OEMs to a greater extent. In such circumstances, the cultural differences inhibiting the smooth management could arise due to the multi-cultural diversity existing in Bangalore and Shanghai for example.

Human resource management (HRM) is relatively more of a problem in general. This is not surprising as the availability of large pool of well qualified scientists and engineers is one of the important driving forces in R&D off-shoring decisions of EU MNEs. However, the recruitment of a large number of suitable candidates is not easy in India and China due to the wide disparity observed in the quality of the technologist and engineers available. Thus even though there is no shortage of the number of people that can be potentially recruited in Shanghai or Bangalore for example, there needs to be a careful selection process. This seems to be relatively more of a problem in India compared to China, and more so in Pharmaceuticals and Automobiles compared to ICT.

Table 7 Important Challenges in Managing the R&D centre -Sub-samples by sectors

Mean Score	*ICT*		*Pharma*		*Auto*		*Overall*	
	China	*India*	*China*	*India*	*China*	*India*	*China*	*India*
Differences between HQ and Centre over objectives or priorities	2.3	1.3	2.3	1.0	2.4	1.7	2.4	1.3
Different practices of managers	3.0	2.0	2.3	1.3	3.0	2.3	2.8	1.9
Human Resource Management problems	2.3	2.3	2.7	4.0	3.0	4.0	2.6	3.2
Attitudes or behaviour of HQ managers	2.3	1.8	2.3	1.3	2.5	1.7	2.4	1.7
Cultural differences	2.3	2.5	2.0	2.0	3.0	3.0	2.4	2.5
Language problems	1.7	1.7	2.0	2.0	3.0	2.0	2.1	1.8
Problems collaborating with external partners	1.7	1.5	2.0	1.3	2.0	1.3	1.9	1.3

Part of the explanation for Human resource problems being relatively less prominent in the ICT sector may be due to the fact that centres have extensive local collaborations with universities and consultancies such as WIPRO in India, who are able to provide the computer engineers and software professionals at the entry level. More of a problem in the sector is the recruitment of experienced mangers for more important roles. Moreover, the attrition rates in this industry at these locations are quite high. As a result there needs to be a sound strategy on motivation, retention and payment in order to neutralise this effect.

4. Summary

A key emerging trend in the globalization of innovation is that an increasing share of R&D is being undertaken in Emerging Markets, especially in India and China. This paper focused on research carried out within the GlobInn project on the involvement EU MNEs in this process. It is based on the views of the managers of R&D centres of 15 EU companies in ICT, Automobiles and Pharmaceuticals, that are active in India and China. We summarize the main results according to the type of activities undertaken by the centres and their strategic drivers, their local embeddedness, autonomy and the managerial challenges.

Activities and Drivers

In the ICT sector the centres are mainly engaged in the development of software, design and engineering. The software related centres undertake specialised functions and mainly respond to project and product development requests from various business units of their parent company. The search for global efficiency has led to the concentration of these specialised functions in a single location thereby reducing duplication. The main reason for choosing India as the location of software development is the availability of a large pool of well qualified software engineers, developers, testers, and technical managers. Essentially, these Indian centres do not cater for local demand but contribute to the parent company's global product development by both developing new products and solutions and improving existing ones.

The ICT centres focusing more on design are concentrated in China and are mainly engaged in hardware design, but also undertake a limited amount of software development. For most centres developing specific features for the local market is only a minor part of their mission. The main strategic drivers for their location choice are availability of skills and cost savings rather than market related factors. However, over time the demand considerations are becoming more important for some of the companies reflecting the growing importance of the prospects of the large and growing market.

Another important finding in relation to evolution of the centres is that many of the centres were initially set up to undertake routine (non-strategic) support functions as a part of a cost-cutting exercise. However, they have gradually undertaken more advanced

and complex tasks as their capabilities have evolved over time. Thus centres that have been present in India over a long period have evolved into taking complete responsibility for global projects. Such projects are now managed by global R&D mangers in India with company employees from other locations reporting to the Indian centre.

In the main the centres of the automobile companies exhibit some of the same features as those in ICT. Thus the Indian centres of the auto component suppliers provide support for product development across the various business units of the company. This takes the form of either software development or the provision engineering services related to both hardware and software. As with ICT centres, there have been an evolution in the tasks being undertaken by the Auto centres. Additionally when the centres were set up in India the local market was of little importance but recently these centres have begun to supply the Indian auto companies as well as started partnering with them.

Some Auto R&D centres in India and China are catering for the demand for low cost products and technologies, by localising existing products and technologies, which involves re-engineering, and implementing cheaper solutions as well as making other adaptations. Few have evolved from explicitly doing localisation to developing entirely new low cost products for the emerging markets.

The EU Pharmaceuticals companies view India and China as important markets and consider it essential to develop the drugs for this market locally for two reasons. Firstly, for the diseases that are prevalent in these markets it is essential that the R&D is undertaken locally. The second reason for locating in India and China is the realization by MNEs that development of low cost drugs is vital in order to succeed in these markets. Another major reason for locating in India and China is to establish linkages with the local Contract Research Organizations (CROS), in order to out-source some routine research. In the case of India such CROs have thrived due to the strong heritage in the production of generic drugs and the highly advanced skills base in Chemistry.

In China there is evidence that centres are undertaking significant amount of research, but as these centres were established very recently and are often small-scale facilities, they are still in very early stages of drug discovery. By establishing R&D centres in China, the Pharmaceutical MNEs are able to undertake joint research with leading institutes and thus scan for new technological breakthroughs.

Local embeddedness

Most of the surveyed R&D centres regardless of sector or country have some collaborative activities with local institutions. They regard such cooperation with other firms, universities and research institutes as an important means to access the complementary technology and resources. For example most of the centres in ICT and Pharmaceuticals have some collaboration with local universities and research institutes. There are some differences in the underlying motives in the two sectors. For example in the ICT sector one of the reasons for linking with universities is to recruit skilled post-graduates. In the case of Phramaceuticals the emphasis is more on connecting with developments in basic research. For the Automotive companies, the local linkages are more with suppliers (in the case of Auto manufacturers) and customers (in the case of Auto suppliers).

Autonomy

In general there is considerable autonomy granted to the centres in our study. More specifically there is greater autonomy in operational and day to day running of the centres, but some of the strategic functions are seen to be steered centrally. Thus the hiring and firing of technical as well as non-technical personnel are at the discretion of the centre. So is the day-to day management of the centres. However, strategic decisions such as budgeting, capital expenditures, decisions on patents and trademarks etc. are undertaken at the centre.

Managerial challenges

The various challenges faced by the R&D centres in our study are quite specific to each sector and the seriousness of these inhibiting factors also differs across India and China. The most important challenge identified is human resource management. This is not surprising as the availability of large pool of well qualified scientists and engineers is one of the important driving forces in R&D off-shoring decisions of EU MNEs. However, the recruitment of a large number of suitable candidates is not easy in India and China due to the wide disparity observed in the quality of the technologist and engineers available. Thus even though there is no shortage of the number of people that can be potentially recruited in Shanghai or Bangalore for example, there needs to be a careful selection process. Even more of a challenge is the recruitment of experienced mangers for more important roles.

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