

Diez, Javier Revilla; Berger, Martin

Conference Paper

The Role of Multinational Corporations in Metropolitan Innovation Systems – Empirical Evidence from Europe and South-East Asia

44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism",
25th - 29th August 2004, Porto, Portugal

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Diez, Javier Revilla; Berger, Martin (2004) : The Role of Multinational Corporations in Metropolitan Innovation Systems – Empirical Evidence from Europe and South-East Asia, 44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism", 25th - 29th August 2004, Porto, Portugal, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/117247>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

The Role of Multinational Corporations in Metropolitan Innovation Systems – Empirical Evidence from Europe and South-East Asia

Javier Revilla Diez, Martin Berger

Chair of Economic Geography, Institute of Geography, Kiel University

Ludewig- Meyn- Str. 14, D-24098 Kiel, Germany; email: diez@geographie.uni-kiel.de

Abstract. Using firm-level survey data from Barcelona, Stockholm, Vienna in Europe and Singapore, Penang (Malaysia) and Bangkok in South-East Asia the paper enquires into the different R&D and innovation behaviour of multinational and local companies in these Metropolitan Regions. Scrutinizing a set of input, throughput and output indicators as well as information on cooperation characteristics, we try to evaluate a) if the spatial pattern of more (intense) innovation activity in Europe when compared to South-East Asia is still valid; and b) if there are reasons to believe that R&D units of multinational corporations in Europe are mainly concerned with the enhancement of the knowledge base and the development of future competitiveness by tapping into localized knowledge and using the particular host regions' innovation systems, while, on the other hand, MNCs in South-East Asia use R&D to support existing production facilities in order to exploit an existing competitive advantage. We are able to show that there is still a major gap in the innovation performance between South-East Asia and Europe and that there are indeed indications that R&D units in Europe are more orientated towards the augmentation of the company's knowledge base.

Introduction

Multinational corporations (MNCs) are an essential mechanism for the internationalization of the transfer of knowledge and technology (Stichweh, 1999). By internationalization, corporations try to use their specific competencies in various markets (Chandler, 1992). They can utilize product, production, marketing and development competencies, which they have accumulated in their home country.

In R&D facilities a gradual move away from a hitherto ethnocentric orientation can be observed since the 1990s. Nevertheless, the corporations still stress predominantly headquarter R&D capacities (cp. Patel and Pavitt, 1998). And the production of new knowledge – as far as it can be measured in patent activities – is still concentrated in the home country or region of the corporation (Archibugi and Mitchie, 1995). Therefore corporate production and innovation concepts are still largely determined by the home location and the respective national and regional characteristics and norms. However, the share of foreign research departments increases steadily with the share of foreign industrial production (OECD, 1998). This supports the thesis that the internationalization of production is followed by the internationalization of research. The R&D departments of corporations are positioned close to production units in order to use the advantages of spatial proximity. The internationalization of production structures is therefore pushing the internationalization of R&D departments.

Contrary to the image of borderless, globally acting corporations, there is evidence that the competencies for research, production and marketing of specific products and services are still to a significant degree regionally concentrated (see Braczyk et al., 1998; Cooke, 2002):

“Microregions are increasingly becoming one of the leading motors of economic development, and gateways of countries to the global market place“ (Dunning, 2000: 29).

Consequently, it can be asked whether, how and in which ways multinational corporations use regional competencies strategically.

The aim of this paper is to shed some light on the interaction between Multinational Corporations' affiliates and their host region's system of innovation. In other words, we try to contribute to the answer to following questions:

- What role do/ can MNCs' subsidiaries play in the development of the host's Regional Innovation System (RIS)?
- And, in turn, how can MNCs benefit from their subsidiaries' host innovation system?

The underlying assumption is that both targets - regional development and company competitiveness – are interrelated. This means that strong regions can start a positive cycle of attracting R&D related FDI, which fosters the RIS, which grows stronger and eventually attracts even more companies.

On the other hand, weak regions could be 'hollowed out' by a vicious cycle of a weak RIS and MNCs that restrict their regional activity to asset exploitation which might not benefit the RIS.

The paper is structured in the following way: First, the theoretical framework is developed by briefly summarizing the reason why companies go multinational. Especially the recent trend of increasing globalisation of corporate R&D activities is highlighted. Second, we give an overview of the theoretical foundation of Regional and Metropolitan Innovation Systems, thereby elaborating the interaction between the MNC and the region and how they can develop to mutual benefit. Third, we present the data used for this study and the methodology with which it was generated and briefly describe the National Innovation System in which the case regions are located. Fourth, we use empirical data from Europe and South-East Asia in order to display similarities and differences in the MNC behaviour in Barcelona, Vienna, Stockholm, Bangkok, Penang and Singapore. Within this part we test two hypotheses: first,

comparing innovation activity in Europe and South-East Asia, innovations are still predominantly performed in Europe. Second, MNC subsidiaries in Europe tend to be more focused on asset augmentation, i.e. in tapping into localized knowledge in order to increase the MNCs knowledge base, while subsidiaries in South-East Asia are rather focused on asset exploitation, i.e. the production of goods. Finally, we conclude with summing up our key findings.

The perspective of the firm – objectives of cross border investments in R&D: exploiting vs. augmenting

A MNC's decision about which location to pick for an overseas investment is related to the motive for this investment. Besides more traditional aspects such as resource or market-seeking aspects, firms also decide in favour of a certain location because of efficiency or strategic asset-seeking motives. The last two decades have witnessed a "rapid growth of strategic asset-seeking FDI, which is geared less to exploiting an existing ownerspecific advantage of an investing firm, and more to protecting, or augmenting, that advantage by acquisition of new assets, or by a partnering arrangement with a foreign firm" (Dunning, 1998: 55). But also more traditional forms of FDI have changed, and foreign subsidiaries are nowadays more embedded in their host economy, have deeper value-chains and perform higher order activities, including R&D (ibid.).

Both processes resulted in a situation where "an increasing proportion of the total R&D expenditure is accounted for by ... [MNCs] foreign subsidiaries" (Dunning, 2000: 16).

The main reasons for globalising R&D functions, which traditionally have been conducted at the home base of the MNC, can be grouped in the following categories: a) market related: to adapt products to local needs, to keep track of customer demands and to give technological back up for important production sites; b) technology related: MNCs try to tap into foreign science and technology (S&T) resources; c) cost related: not only the labour costs for

engineers and scientists vary globally, but in some industries the supply of high class scientists at the home base might simply be not sufficient to sustain the MNC's R&D efforts; d) technology monitoring: to monitor new developments in S&T or to analyse competitors; e) non-R&D related: national governments might connect market access to the establishment of R&D facilities (e.g. in pharmaceuticals), or a company might want to improve its image by showing commitment to the host region by transferring R&D functions (Reddy, 2000).

Combining types and motives of foreign R&D facilities produces a dichotomy of the following two types of R&D FDI: units that are concerned with the exploitation of the firm's knowledge stock and units that aim at augmenting that existing knowledge stock of the firm (Kuemmerle, 1999). Kuemmerle labels these types of R&D facilities 'home-base-exploiting' (HBE) and 'home-base-augmenting' (HBA) FDI.

HBE is responsible for adapting existing products to local needs and transferring knowledge and prototypes from the firm's home location and therefore follows existing production abroad (see also Hotz-Hart, 2000). There is evidence that much of the technology that is developed by MNCs abroad still falls into the core areas of the firms' competence, "suggesting that adaptation and technical support to foreign manufacturing plants continues to be a major explanatory factor" (Cantwell and Iammarino, 2003: 4) for the dispersion of multinational R&D activities.

In contrast, HBA has the task of extending existing core competencies and of broadening the knowledge base of the firm. Its requirements on a location are fairly different from HBEs. In order to participate in innovative networks, to benefit from spillovers and to tap into local knowledge they need to be located in agglomerations that host a high density of high-class R&D facilities (public or private), service companies and institutions as well as a large pool of highly educated engineers and scientists (e.g. Ivarsson and Jonsson, 2003). Furthermore, different locations offer different specialisations, and it is necessary for MNC to 'be there' in

order to make use of this localized knowledge. Reddy evaluates this access to “a wide range of innovative stimuli and sources of scientific creativity” (2000: 27) as the key driving force behind the globalization of R&D by MNCs.

Even though this kind of localized knowledge is increasingly distributed internationally, it is predominantly sited within the Triad of Europe, Japan, and North America (Hotz-Hart, 2000; Dunning, 2000). Still more than 90% of the world’s industrial R&D is still carried out within the industrialized world (Reddy, 2000). These locations of innovative stimuli, key knowledge and sources of creativity are not evenly distributed within the industrialized world, but there is “some suggestion that the major metropolitan areas and their surrounding hinterlands are becoming the loci of agglomerative knowledge enhancing activity” (Dunning, 2000: 125).

The perspective of the region – From national to metropolitan systems of innovation

Since the mid-1980s research about innovation processes has been increasingly directed to the analysis of national systems of innovation (Freeman and Soete, 1997). The systems of innovation concept interprets innovation as a systemic and complex process, which is not seen as a linear sequence, as in the neoclassical view, and not only dependent on one single entrepreneur's decisions. Instead, it is accepted that innovation is a result of intensive interactions between different actors within and outside a firm and therefore depending heavily on relationships between the firm and its environment. The business environment influences the firm's innovation activities in two ways. On the one hand, innovative firms use the cooperation with other actors to access information, knowledge and other resources, to exchange experiences, and to find jointly adequate solutions. Potential cooperation partners are other firms, for example customers, suppliers, competitors, service providers and/or research institutes, financial institutions, political decision-makers etc. On the other hand, the social and cultural embeddedness, the institutional and regulatory framework and the existing

infrastructure influence entrepreneurial decisions. In this sense, innovation is the outcome of an interplay between different actors, whose actions are determined by their environment (Camagni, 1991; Crevoisier, 1998; Hudson, 1999).

Whereas Lundvall (1992) and Nelson (1993) concentrate their analysis on the nation state, much more attention has been paid to the regional level since the mid-1990s which led to a fairly high number of studies about regional innovation systems (e.g. Cooke and Morgan, 1998; Braczyk et al., 1998; Maskell et al., 1998). The authors transfer the systemic elements of a national innovation system to the regional level. In short, they argue that region-specific conditions and cooperation relationships between different actors influence the regional innovation potential either positively or negatively. However, it would be wrong to interpret regional innovation systems as being isolated from the national and/ or international context. The national scale continues to be crucial in setting important framework conditions like laws and investment (e.g. in research and education). The international scale gives important impulses about potential markets and the development of new products; it also provides knowledge from outside the region (Revilla Diez, 2000).

Recent studies about the spatial distribution of innovation activities show that metropolitan regions have a high innovation potential (e.g. BMBF, 2000 for Germany; Brouwer et al., 1999; Varga, 1998; Anselin et al., 1997 for the USA; Feldman and Audretsch, 1999).

These results underline that metropolitan regions offer favourable conditions for innovating firms. Here, innovating firms find a qualified work force, capable cooperation partners in business and research institutes (Suárez-Villa and Fischer, 1995; Howells, 1983; Ewers and Wettmann, 1980). Furthermore, spatial, technological and institutional proximity and specific resources are available that can generate significant externalities (Fischer et al., 2001). For these reasons metropolitan regions can be interpreted as metropolitan innovation systems

which tend to be the driving forces in national and global innovation processes (Fischer et al., 2001; Shefer and Frenkel, 1998).

However, the importance of ‘simple physical’ or geographical proximity for interactive learning processes, which is at the heart of the concepts of regional and metropolitan systems of innovation, has been questioned. There is no doubt about the benefits of being co-located for organizing face-to-face contacts and frequent interaction, but relational or organizational proximity are supposed to be even more important, allowing for easy knowledge transfer via modern telecommunication even over wide distances (e.g. Amin, 2000: 14; Gertler, 1995: pp.4). However, “the idea that organizational or relational proximity is sufficient to transcend the effects of distance (even when assisted by telecommunications and frequent travel) seems improbable” (Gertler, 2001: 19). Furthermore, even MNCs are still strongly influenced by national and to a certain degree regional conditions. At the one hand, they “forever bear the markings or imprints of their national origin” (ibid.: 14) but at the same time their practices are strongly shaped by the national institutions of their host regions. Additionally, Gertler recognises the possible impact by regional factors (e.g. industrial relations regimes, education and training systems), which have received “surprisingly little attention thus far” (ibid: 21). Therefore, a multi-scale approach which takes into account different spatial and non-spatial systems of innovation and their intertwining seems necessary (e.g. Bunnell and Coe, 2001; Revilla Diez and Kiese, 2004).

To sum up, the quality of an RIS or MIS depends on the quality and quantity of actors and the linkages between them. Furthermore, the regional knowledge base is the result of an evolutionary, cumulative process of learning. In this process it is important to secure a steady inflow of outside knowledge resources, either by attracting new actors from outside into the region or by having local actors with the capability to tap into outside knowledge (Cantwell and Iammarino, 2003). In both mechanisms MNC play a crucial role, because they can be

attracted to a region and they sustain strong links to the outside world. Cantwell and Immarrino see them therefore as “the key ring of the chain from global to local” (2003:18).

MNCs, on the other hand, use the different national and regional competencies specifically and strategically – e.g. by supplier-client-relationships, research and development co-operations, the recruitment of labour and special producer-client relationships (lead customers), as was elaborated by various contributions to the debate on regional and national innovation systems (Braczyk et al., 1998; Edquist, 1997; Lundvall, 1992; Nelson, 1993). It can be assumed that the strengths of MNCs derive from the possibility to learn in different regional contexts (see Ivarsson, 2002). However, since different national/ regional institutional settings shape MNCs practices and the processes in which new knowledge is created, combining the knowledge from different locations is just as challenging as the transfer of good practice even for “global firms with deep resources” (Gertler, 2001: 19). Building on these theoretical reflections the aim of the paper is to investigate the following key questions:

- The traditional spatial pattern of R&D activity suggests that MNCs would perform much more R&D in Europe than in South-East Asia. Is this picture still valid for successful latecomers like Singapore vis-à-vis European Metropolitan Regions?
- Is there evidence to support the hypothesis that MNCs in Europe tend to be more involved in home-base-augmentation while MNC in South East Asia are more orientated towards home-base-exploitation?

Data/ Methodology

Since the 1970's numerous innovation and network studies have been conducted on a national and regional scale. However, a basic problem is their lack of comparability. The European Regional Innovation Survey (ERIS) was a comprehensive and integrated attempt to overcome

this shortcoming. Using written questionnaires, the most important actors in eleven regional innovation systems across Europe were surveyed, namely manufacturing firms, producer services and research institutions, in order to analyse their innovative and networking activities. Basically the same actor-specific questionnaires were used in all the regions surveyed, guaranteeing a high degree of comparability (Fritsch et al., 1998).

When designing the questionnaires for the postal surveys in Singapore, Penang and Thailand, the core elements of the ERIS questionnaires were retained. It includes information about firm characteristics (age, size in terms of turnover, capital stock, and employees, sector, ownership etc.), innovation activities (R&D personnel and expenditure, patents, new products etc.) and innovation co-operation (with customers, suppliers, parent companies, universities etc.).

This paper focuses on the results from the six metropolitan regions Barcelona, Stockholm and Vienna in Europe and Bangkok, Penang and Singapore in South-East Asia¹. The regions are defined in a functional perspective. In addition to the city core area the industrial hinterland is included. Table 1 gives an overview of the spatial extension of the metropolitan regions.

Table 1. Size of the six metropolitan case regions

Metropolitan Region	...encompassing:
Stockholm	Provinces of Stockholm, Uppsala, Södermanlands, Örebro and Västmanlands
Vienna	City of Vienna and districts of Baden, Bruck an der Leitha, Gänserndorf, Korneuburg, Mödling, Tulln and Vienna vicinity
Barcelona	Communities of Barcelona, Baix Llobregat, Valles Occidental, Valles Oriental and Maresme.
Singapore	City of Singapore
Penang	State of Penang
Bangkok	Provinces of Bangkok, Nonthaburi, Pathum Thani, Nakhon Pathom, Samut Sakhon, Samut Prakan, Ayutthaya, Chachoengsao, Chon Buri and Rayong.

Table 2 gives an overview of the populations, sample sizes, response rates and year of the surveys. While in Europe and Penang all sectors and all companies were included, in Singapore only companies in the dominating industry clusters (electronics, chemicals,

¹ For a comprehensive analysis of the three European regions see Fischer et al. (2001) and Revilla Diez (2002b; 2002c), for Singapore refer to Kiese (2004) and for Penang to Stracke (2003). Thailand related details can be found in Intarakumnerd et al. (2002). A general overview and comparison of the three South-East Asian surveys has recently been published by Kiese and Revilla Diez (2004).

engineering and life sciences) were surveyed (Kiese, 2004) and in Thailand out of the total population of companies a sample frame was obtained by using a three-stage sampling procedure (Brooker Group, 2001; Virasa and Brimble, 2001).

Overall, the comparison between the survey data and the population shows that the data set is a good representation of the total population in terms of sector affiliation (for details see Revilla Diez, 2002a ;Kiese, 2004; Schiller, 2003). Only the sample in Penang displays some systemic bias towards chemicals, electronics and fabricated metal products (Stracke, 2003).

Table 2. Year of Survey, responses and response rates (manufacturing only) in the six metropolitan regions

Region	Country	Year ¹	Population	Sample	Responses	Response rate
Europe						
Barcelona	Spain	1997	2,650	2,650	395	14.9%
Stockholm	Sweden	1997	1,879	1,879	451	24.0%
Vienna	Austria	1997	908	908	204	22.5%
South-East Asia						
Singapore	Singapore	1999	2,665	1,865	374	20.0%
Penang	Malaysia	2000	951	921	192	20.8%
Bangkok	Thailand	2000	35,000 ²	2,166 ²	928	47.0% ²

¹ launch; ² figures for nationwide survey

Data: European Regional Innovation Survey; EDB/NUS-CMIT National Innovation Survey Singapore; Penang State Innovation Survey; Thailand R&D/Innovation Survey 2000

Since the survey focused on companies of the manufacturing sector, it only includes information on R&D units that are included in production facilities. We do not consider any information on independent R&D laboratories.

Our definition of MNCs is a rather broad one: all companies that are somehow influenced by foreign owners, no matter how much of the total company is controlled by the foreign partner, have been labelled as MNC. We believe that this definition is justified, because even minor foreign shareholders/ owners might exercise their influence to use the joint venture partner's facilities to access new knowledge pools and feed them into its own global network, or to restrict its objective to production support and adaptation functions.

A further restriction of the data analysis is that we only scrutinize data for one segment of the industry: metal products, machinery, equipment and electronics (ISIC codes 28-35). Cross

country comparisons require this kind of limitation, because otherwise the results will be distorted by the differences in the economic structure.

The Case Study Regions – some secondary indicators for characterising the National Innovation Systems

The basic S&T indicators in table 3 display some features of the NSIs that determine the innovation potential in the six case study regions.

While the European countries in general are far advanced, the NSI of Spain, Sweden and Austria show some marked differences. With respect to innovation, Sweden is the most successful country, reaching top positions in the IMD world competitiveness rankings with respect to gross domestic expenditure on R&D as % of GDP (GERD) and the share of R&D personnel per capita (e.g. IMD, 1998, 1999, 2001, 2002, 2003, 2004). Additionally, much of the R&D expenditure in Sweden is funded by private business enterprises, which results in a high number of patents in force per 100,000 inhabitants as well as a patent application rate (patent application per capita) at the European Patent Office twice as high as the EU average (OECD, 1999). In contrast, the Austrian NSI shows some weaknesses: GERD, the number of R&D personnel per capita as well as R&D expenditure by business enterprises in % of all funds (BERD) are clearly lower, resulting only in a medium rank in the IMD ranking (e.g. rank 20 for GERD in 1996). Despite a fairly high number of patents in force, the Spanish NSI is the weakest of the three European NSI, with a GERD only half of the EU average (OECD, 1999), a low number of R&D personnel (especially in the business sector) and a small share of private R&D expenditures.

Table 3. Overview of the key indicators of the National Systems of Innovation in the six case study countries: GERD, BERD, R&D personnel in total and in business, number of patents in force

Country	GERD		BERD		Total R&D Personnel*		R&D Personnel in Business*		Number of Patents in Force [§]	
	1996	2002	1996	2002	1997	2002	1997	2002	1996	2001
Europe										
Spain	0.84	0.96 ²	48.6	52.4 ²	2.26	3.12 ²	0.79	1.15 ²	391.7	251.6
Sweden	3.59	4.27 ²	74.4	77.6 ²	7.40	8.11 ²	4.72 ⁵	5.55 ²	1,076.4	1,097.5 ⁷
Austria	1.51	1.93	41.2 ³	77.2 ⁴	3.88 ⁴	3.88 ⁴	2.52 ⁴	2.52 ⁴	193.0	144.7
South-East Asia										
Singapore	1.37	2.15	63.3	61.4	3.23	5.24	2.12	2.75	368.4	704.2
Malaysia	0.20 ¹	0.71	72.8 ¹	65.6	0.21	0.52	0.11	0.26	28.6 ⁶	2.3
Thailand	0.13	0.26	20.2	42.1	0.23	0.51 ²	0.01 ⁵	0.11	4.2 ⁴	2.6 ⁷

¹1997, ²2001, ³1993, ⁴1998, ⁵1995, ⁶1994, ⁷2000

Source: IMD, 1998, 1999, 2001, 2003, 2004

* in full time work equivalent per 1,000 people; [§] per 100,000 inhabitants

When these figures are compared with the data from South-East Asia, it is striking that Singapore is doing quite well when it comes to allocating resources for R&D. GERD is almost as high as in Austria. The number of R&D personnel per capita even ranks second of the six regions considered, behind Sweden.

On the other hand, Malaysia and Thailand lag behind quite significantly, with a very low GERD and R&D personnel intensity. Additionally, the number of patents in force is significantly lower than in the other countries.

In conclusion, the European NSI are quite mature but show different levels of excellence. Singapore has obviously managed to catch up in allocating resources to innovation processes. The NSI in Malaysia and Thailand still lag behind markedly.

It can therefore be assumed that investment by MNCs in R&D facilities in Europe could be of the HBA type, since the S&T environment conditions favour this kind of activity. At the same time, not all the three European regions offer the same high quality standard, and therefore the analysis of the micro-level data is needed to see if some differences between these regions can be observed.

For the South-Asian regions, the secondary data for Singapore is in almost all aspects at the same level as the figures for the European regions: can this positive evaluation be confirmed by the micro level data? In contrast, the general data for Thailand and Malaysia look quite

gloomy: what is the situation like in the two national economic powerhouses of Bangkok and Penang? Does the data give reason to believe that the agglomerations do better in innovative terms than the country as a whole?

Innovation capabilities compared

The brief summary of available secondary data confirms the first assumption that R&D activities are still stronger in EU than in South-East Asian countries. While Singapore has managed to increase its innovation activities, Thailand and Malaysia commit far less resources to innovation activities.

The summary of key innovation indicators in table 4 shows that there is still a major gap between innovation activity in South-East Asian and European Metropolitan Regions. This result supports the argument that most of the R&D is still performed in industrialized regions of the triad. Furthermore, the data displays that Singapore and Penang are at a similar level, clearly in an intermediate position between the European regions and the 'laggard' Bangkok. Consequently, the picture of Singapore as an advanced country with respect to innovation, that has been sketched by the secondary data, does not hold true for the micro-level survey data. Obviously the secondary data is a snapshot, displaying the commitment towards the development of a knowledge-intensive economy. The firm-level data on the other hand are rather the result of a long-term development. And this development in Singapore just started in the late 1980s (Kiese, 2004) and is still characterised by a strong focus on applied research. The same is true for Penang, where the main objective of the companies is seen in the assembly of components with hardly any tasks in earlier (design/ R&D) or later (marketing) tasks along the value chain (Stracke, 2003).

Table 4. Selected input, throughput and output indicators: Share (%) of companies that ...

	...perform R&D	...obtained at least one patent	total ¹	... are innovating: product ²	process ³	... are innovative ⁴
Europe						
Barcelona (n=147-159)	73.6	35.8	89.3	83.2	78.2	35.8
- Local Firm	74.8	35.9	91.6	82.4	77.2	35.1
- MNC	67.9	35.7	78.6	87.5	83.3	39.3
<i>Significance</i> *	<i>0.449</i>	<i>0.987</i>	<i>0.083[#]</i>	<i>0.767[#]</i>	<i>0.508</i>	<i>0.676</i>
Stockholm (n=203-243)	77.8	34.5	69.5	61.3	46.8	25.9
- Local Firm	77.2	31.4	66.8	58.7	42.9	23.9
- MNC	79.7	44.7	78.0	69.5	58.2	32.2
<i>Significance</i> *	<i>0.689</i>	<i>0.093</i>	<i>0.106</i>	<i>0.138</i>	<i>0.049</i>	<i>0.206</i>
Vienna (n=63-71)	74.6	49.2	87.3	81.2	69.0	33.8
- Local Firm	80.9	48.8	85.1	78.3	59.6	23.4
- MNC	62.5	50.0	91.7	87.0	87.5	54.2
<i>Significance</i> *	<i>0.093</i>	<i>0.932</i>	<i>0.708[#]</i>	<i>0.520[#]</i>	<i>0.016</i>	<i>0.010</i>
South-East Asia						
Singapore (n=265-266)	26.0	5.3	38.7	28.9	29.7	12.8
- Local Firm	17.1	1.4	27.7	16.3	21.3	7.1
- MNC	36.0	9.6	51.2	43.2	39.2	19.2
<i>Significance</i> *	<i>0.000</i>	<i>0.003</i>	<i>0.000</i>	<i>0.000</i>	<i>0.001</i>	<i>0.003</i>
Penang (n=90-91)	32.2	6.6	46.2	38.9	44.4	18.9
- Local Firm	33.3	4.8	45.2	35.7	42.9	16.7
- MNC	31.3	8.2	46.9	41.7	45.8	20.8
<i>Significance</i> *	<i>0.833</i>	<i>0.683[#]</i>	<i>0.871</i>	<i>0.563</i>	<i>0.777</i>	<i>0.614</i>
Bangkok (n= 303)	14.5	2.6	18.8	13.2	14.5	5.0
- Local Firm	19.0	2.5	26.4	19.0	19.8	7.4
- MNC	11.5	2.7	13.7	9.3	11.0	3.3
<i>Significance</i> *	<i>0.071</i>	<i>1.000[#]</i>	<i>0.006</i>	<i>0.015</i>	<i>0.032</i>	<i>0.104</i>

* Asymptotic Significance according to Pearson's Chi-Square Test, two-sided

[#] Exact Significance according to Fisher's Exact Test, two-sided (used if at least one cell with expected frequency <5)¹ innovating, total: companies that either introduced a new/improved product into the market or introduced a new process in the 3 years prior to the survey² innovating, product: companies that introduced a new/improved product into the market in the 3 years prior to the survey³ innovating, process: companies that introduced a new process in the 3 years prior to the survey⁴ innovative: companies whose share of new/improved products (introduced in the 3 years prior to survey) of total sales is at least 25%

Comparing MNCs and local companies, it can be shown that MNCs in Bangkok are significantly less likely to conduct product or process innovation than local companies. The pattern in Singapore is just the other way round, with significantly more MNC participation in

all available innovation indicators. In Penang the difference is less striking, but here the results also show some higher activity by MNCs than by local companies.

In the European regions the differences between local and multinational firms are quite small. Both types of companies are engaged more strongly in product than in process innovation.

The high percentage of companies (also MNCs) that obtained a patent could be an indication of the more HBA orientated activity in Europe compared with South-East Asia, since it can be assumed that the accumulation of new knowledge feeds into the development of patentable designs, products or processes. HBE-supporting activities, like the technical back-up of production processes or the local adaptation of products might, on the other hand, not be protected by patents. Furthermore, the Asian-based companies show a clear tendency rather to conduct process than product innovations (the only exception are MNCs in Singapore), while in Europe companies perform more product innovations. This result points towards a certain division of labour as proclaimed by the notion of the 'new division of labour' (see e.g. Fröbel et al., 1980): Asian companies seem to be more concerned with efficiency-enhancing process improvements that increase productivity and reduce costs. This indicates that their competitive advantage/ core competence seems to lie in the cost efficient production of goods, and not in the development of the product design. The latter is mostly brought in from Triad countries. Typical firm strategies would be the OEM (Original Equipment Manufacturing; (Hobday, 1995, 2000) led growth or other more process-oriented specialisations (e.g. see Wong, 1999): between 65-70% of the firms in Bangkok, Penang and Singapore are either OEM or manufacturing arm companies, which manufacture products according to design specifications provided either by external customers or parent companies (Revilla Diez and Berger, 2004).

On the other hand, European-based companies are as, or even more, likely than their Asian counterparts to improve existing process technology, but they are even more active in developing new products. Of course, process improvements are important for the competitiveness of a company, but new products are essential for the future competitiveness and market position of the company. And these investments in the future are obviously made more often in European regions, which can be explained by the proximity to demanding lead markets, offering easy access to market intelligence, specialised services and all important user-producer linkages, as well as to a pool of highly qualified human capital and excellent centers of basic and applied research (Wong, 1999; Hobday, 2000; Fischer et al., 2001).

In order to investigate the commitment to innovation activities of the companies in Europe and South-East Asia, tables 5 and 6 as well as figure 1 show the resource input into the R&D process by multinational and local companies. We therefore have grouped the companies according to their R&D expenditure per sales. This is a common approach for distinguishing different technology intensive industries. BMBF (2000) classifies three groups: low technology (less than 3.5% R&D expenditure/ sales), medium technology (3.5 – 8.5%) and high technology industries (> 8.5%). Due to different class-sizes, these classifications could only approximately be resembled.

In R&D expenditure/ sales as well as R&D personnel/ employees local companies assign significantly more resources to the R&D process for the total sample. Comparing the Asian with the European Metropolitan Regions it can be shown that MNCs in Europe devote more and MNCs in South-East Asia commit less resources to R&D than local companies.²

² One has to take into account a possible influence of the 1997 Asian financial crisis on the R&D expenditure by companies. While GERD in Singapore did not decrease, there are contradictory data for Thailand and in Malaysia GERD already decreased in 1996 (IMD, 1998, 1999; Mani, 2004; NSTDA, 1999; UNESCO, 2004), therefore private R&D expenditure might be lower than before the crisis. However, the structural pattern is very unlikely to be distorted and the additional presented data is more persistent and underlines the sketched picture. Rather, we agree with Intarakumnerd et al., 2002 that the severeness of the Asian crisis in Thailand is a result of the poorly developed innovation system (see conclusion).

Even Singapore-based companies display a higher resemblance with MNCs in Penang and Bangkok than with MNCs in the European regions: about 63% of the MNCs invest less than 3% of sales in R&D, and the pattern of local companies having a higher R&D personnel intensity than MNCs holds true for Singapore as well. Nevertheless, the total share of R&D personnel in Singapore is clearly higher than in the other Asian regions, reaching levels similar to or even higher than in Europe. Within Europe, Stockholm is conspicuously different from Barcelona and Vienna. A large share of MNC in Stockholm is found in the high technology or medium technology sector, while MNCs in Vienna and Barcelona are most frequently in the medium technology industry, and hardly reaching high technology levels. In these regions local firms dominate the high technology sector.

This pattern is also reflected by the R&D personnel intensity, which is fairly high for Stockholm based MNCs and clearly lower for MNCs in Barcelona and Vienna; in Barcelona the average of MNCs is even below the average of local companies.

Table 5. R&D expenditure per sales and share of R&D personnel of total workforce of local and multinational companies in Europe and South-East Asia

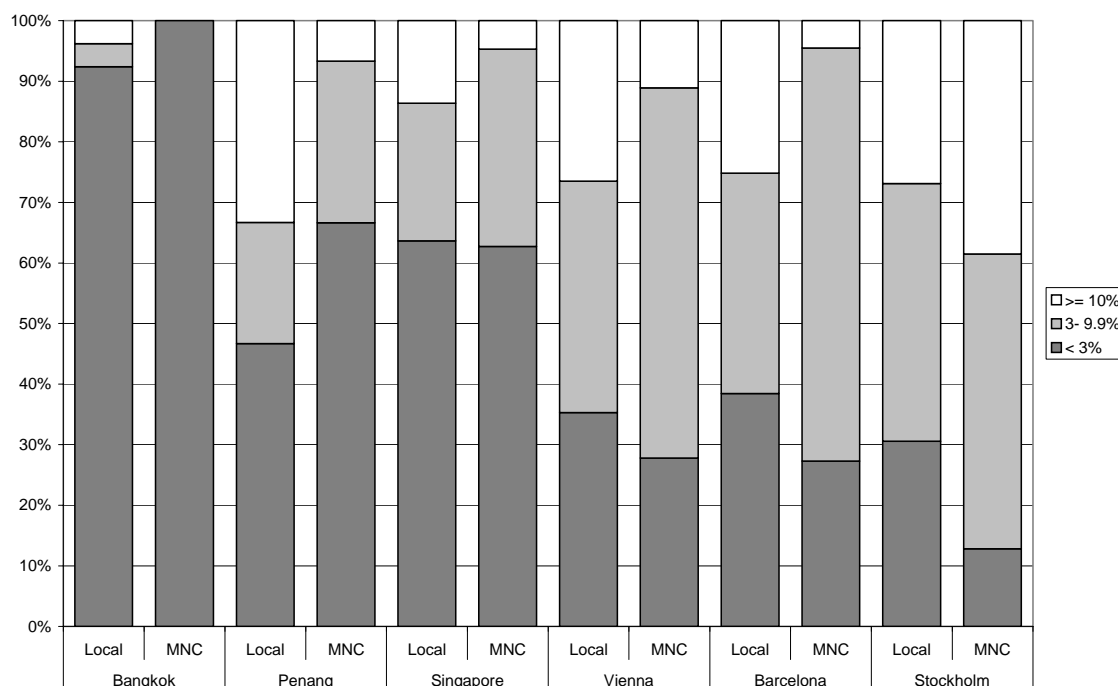
	Total		Europe		South-East Asia	
R&D expenditure per sales						
	Local Firm (n=330)	MNC (n=222)	Local Firm (n=240)	MNC (n=79)	Local Firm (n=90)	MNC (n=132)
< 3%	46.4%	62.2%	34.6%	20.3%	77.8%	85.3%
3-9.9%	31.8%	28.4%	39.6%	57.0%	11.1%	12.6%
>= 10%	21.8%	9.5%	25.8%	22.8%	11.1%	2.1%
<i>Significance</i> [*]	0.000		0.016		0.014	
R&D personnel/ employees (%)						
	Local Firm (n=424)	MNC (n=296)	Local Firm (n=305)	MNC (n=97)	Local Firm (n=119)	MNC (n=199)
Mean	7.43%	4.40%	8.60%	10.46%	4.45%	1.44%
<i>Significance</i> ⁺	0.000		0.256		0.002	

* Pearsons's Chi-Square Test, ⁺ t-Test

Table 6. Average of R&D personnel/employees (%) of local and multinational companies in the six Metropolitan regions

	Local Firm	MNC
Europe		
Barcelona	7.69	6.22
Stockholm	9.81	13.22
Vienna	6.94	8.77
South-East Asia		
Singapore	12.49	6.00
Penang	4.97	2.14
Bangkok	2.36	0.06

Figure 1. R&D expenditure per sales of local and multinational companies in the six Metropolitan regions



Asked to evaluate the availability of qualified personnel more generally in their host region, a higher share of companies in Europe were satisfied with the human capital (see table 7). Even though there are no significant differences between MNC and local firms in the regions (Chi-Square Test), a certain pattern evolves: MNCs in South-East Asia less frequently evaluate the availability positively than local companies, while in Europe it is just the other way round, indicating that this might be one reason why MNCs set up facilities in these regions. The quite negative evaluation in Stockholm could be an indication of a lack of suitable manpower in the scientific as well as business sector due to a very high demand (as indicated by the high share of R&D personnel/ employees in MNCs) in this thriving region. Presumably this shows agglomerative disadvantages that are not yet experienced in the other European regions. In Bangkok and presumably Penang it is rather a lack of human capital caused by insufficient numbers of qualified people, especially in science and engineering, that causes the dissatisfaction: in 1998 in Thailand 18% of graduates were from S&E courses (Alpha Research, 2003; cf. Intarakumnerd, 2004), compared with 35% in Singapore (Ministry of Education Singapore, 2004), 22% in Spain, 23% in Austria and 51% in Sweden (EC, 2002;).

Table 7. Share of companies that assessed the availability of manpower as good or very good

	Availability of suitable manpower in scientific- technical sector		Availability of suitable manpower in business sector	
	Local Firm	MNC	Local Firm	MNC
Europe				
Barcelona	52.4	69.6	46.0	57.1
Stockholm	25.0	25.0	17.0	25.0
Vienna	33.3	57.9	43.9	57.9
South-East Asia				
Singapore	24.1	22.4	27.7	23.2
Penang	19.0	10.2	21.4	18.4
Bangkok	20.7	15.4	20.7	17.6

Cooperation Pattern

In this section we will examine how the companies that actually perform either product or process innovations differ with respect to their cooperation behaviour with external partners (see table 8).

The data depicted in table 8 leads to the following conclusions:

First, obviously cooperation is a key feature of innovating companies in all six regions. In all regions a high and similar share of innovating companies cooperate with external partners in their innovation activities. Furthermore, all regions exhibit a similar ranking of cooperation partners: customers are the most frequent cooperation partner followed by suppliers and service providers. This pattern has already been observed in all eleven regions of the ERIS-project (see Sternberg, 2000). Vertical linkages to suppliers and customers are more important in the innovation process of companies than horizontal linkages to service providers or research institutes, thus confirming Lundvall's (1985) findings. This is also valid for firms in South-East Asia.

Table 8. Share (%) of all innovating companies that collaborate (at any intensity) with the following external partners

Region	Any Partner	Customer	Supplier	Business Service Provider	Technical Service Provider	Research Institution/ University	Other company/ Competitor
Europe							
Barcelona (n=142)	92.3	67.6	56.3	31.0	55.6	22.5	22.5
- Local Firm	91.7	66.7	51.7	30.0	54.2	19.2	19.2
- MNC	95.5	72.7	81.8	36.4	63.6	40.9	40.9
<i>Significance</i> [*]	<i>1.000</i> [#]	<i>0.577</i>	<i>0.009</i>	<i>0.553</i>	<i>0.411</i>	<i>0.048</i> [#]	<i>0.048</i> [#]
Stockholm (n=169)	89.9	75.1	39.1	32.5	38.5	36.7	18.9
- Local Firm	87.8	70.7	38.2	29.3	31.7	30.1	20.3
- MNC	95.7	87.0	41.3	41.3	56.5	54.3	15.2
<i>Significance</i> [*]	<i>0.160</i> [#]	<i>0.030</i>	<i>0.714</i>	<i>0.137</i>	<i>0.003</i>	<i>0.004</i>	<i>0.451</i>
Vienna (n=62)	88.7	53.2	33.9	40.3	40.3	32.3	19.4
- Local Firm	82.5	45.0	25.0	32.5	32.5	27.5	20.0
- MNC	100.0	68.2	50.0	54.5	54.5	40.9	18.2
<i>Significance</i> [*]	<i>0.044</i> [#]	<i>0.080</i>	<i>0.047</i>	<i>0.090</i>	<i>0.090</i>	<i>0.280</i>	<i>1.000</i> [#]
South-East Asia							
Singapore (n=103)	98.1	94.2	85.4	56.3	73.8	70.9	51.5
- Local Firm	97.4	97.4	82.1	51.3	66.7	53.8	56.4
- MNC	98.4	92.2	87.5	59.4	78.1	81.3	48.4
<i>Significance</i> [*]	<i>1.000</i> [#]	<i>0.404</i> [#]	<i>0.447</i>	<i>0.422</i>	<i>0.200</i>	<i>0.003</i>	<i>0.432</i>
Penang (n=42)	97.6	97.6	90.5	73.8	81.0	61.9	76.2
- Local Firm	100.0	100.0	84.2	73.7	84.2	52.6	73.7
- MNC	95.7	95.7	95.7	73.9	78.3	69.6	78.3
<i>Significance</i> [*]	<i>1.000</i> [#]	<i>1.000</i> [#]	<i>0.313</i> [#]	<i>1.000</i> [#]	<i>0.709</i> [#]	<i>0.261</i>	<i>1.000</i> [#]
Bangkok (n= 57)	71.9	70.2	59.6	33.3	47.4	42.1	49.1
- Local Firm	75.0	71.9	59.4	28.1	43.8	50.0	53.1
- MNC	68.0	68.0	60.0	40.0	52.0	32.0	44.0
<i>Significance</i> [*]	<i>0.559</i>	<i>0.751</i>	<i>0.962</i>	<i>0.345</i>	<i>0.536</i>	<i>0.172</i>	<i>0.494</i>

^{*} Asymptotic Significance according to Pearsons's Chi- Square Test, two- sided

[#] Exact Significance according to Fisher's Exact Test, two-sided (used if at least one cell with expected frequency <5)

Second, more innovating companies in Penang, Singapore and partly in Bangkok cooperate with external partners than companies in Europe, which might be caused by a lack of in-house innovation resources in terms of funds and personnel (e.g. see table 5 and 6) as well as 'expertise', because many latecomer-firms are still rather inexperienced when it comes to

innovation activities. This is clearly the case in Thailand (see Arnold et al., 2000; Brimble, 2003 and Intarakumnerd et al., 2002) and it is also still valid for Malaysia, although at a different level (Ariffin and Figueiredo, 2002; Hobday, 1999 and Rasiah, 2003). In Singapore, there is a recent trend of major upgrading in R&D capabilities, especially by MNCs (Wong, 1998, 2003), which is displayed by fairly high R&D intensity in terms of personnel. However, there is still a significant gap in terms of R&D expenditure between European and Singaporean firms (ca. 63% of both local and foreign firms spend less than 3% of sales for R&D, compared to 12-28% of firms in Europe). Additionally, firms size (measured in employees) in South-East Asia tends to be larger than in Europe. Since empirical studies found that size and propensity towards co-operation correlates (e.g. Colombo, 1995; Munier, 2004 (forthcoming); Kiese, 2004), this would partly explain the pattern, even though the innovation indicators are too different between Asia and Europe to solely rely on this explanation.

A second explanation for the larger share of co-operating companies in South-East Asia can be found in the higher degree of external control over local and multinational companies alike (Kiese and Revilla Diez, 2004), either directly by the parent company or through hierarchies within global production networks (Henderson et al., 2002; Ernst, 2002).

Third, there is a tendency that more local firms than MNCs cooperate with customers in South-East Asia, while in Europe it is just the other way round. This supports the observation that more Europe-based MNCs are product innovators, which requires close collaboration with possible customers, while MNCs in South-East Asia are more concerned with process innovations. Nevertheless, the share of South-East Asia based MNCs that cooperate with customers is remarkably high, indicating that the MNC-headquarters' objective even for their Asian affiliates follows a Local-for-Local or even Local-for-Global strategy. The first describes a strategy where the MNC subsidiary develops products for important markets

locally, while the latter depicts local development activities for the global market.

Traditionally, MNC have used a Centre for Global strategy, where R&D was concentrated at the home base of the company (Ghoshal and Barlett, 1990).

Fourth, apart from Bangkok, in all other regions MNCs use the possibility to cooperate with research institutes or universities more frequently than local companies. This is significant at the 5%-level for Singapore, Barcelona and Stockholm. Assuming that the objective of these linkages is to enhance the knowledge base of the MNC, our conclusion is that a high share of collaboration with these kinds of institutions is an indicator of a high share of HBA-type MNC affiliates. On the other hand, we lack information on the type and intensity of the knowledge transfer taking place in these networks, and therefore can only suppose that Europe- and to a certain extent Singapore- based MNC affiliates try to tap into pools of localized, new knowledge, while certainly in Bangkok, and presumably in Penang, the quality of the local S&T infrastructure is not sufficient to attract much MNC involvement.

The overall spatial distribution of cooperation partners (see figure 2 for any partner and figure 3 for universities and R&D institutes) shows that MNCs in Penang and Singapore are much more outward-looking than MNCs in the European metropolitan regions. In Penang as well as in Singapore, partners in the rest of the world are frequently sought by the surveyed MNCs, while in Europe the region and the nation (Stockholm) or the region and the EU (Barcelona) are the source of most of the cooperation partners. Only MNCs in Vienna cooperate as often regionally as globally.

The spatial pattern can be explained by a) the importance of customers and suppliers in demanding lead markets for co-operation in product or process development, b) the quality and quantity of suitable cooperation partners which is clearly higher in the European innovation systems due to the maturity of the systems and the 'traditional' international

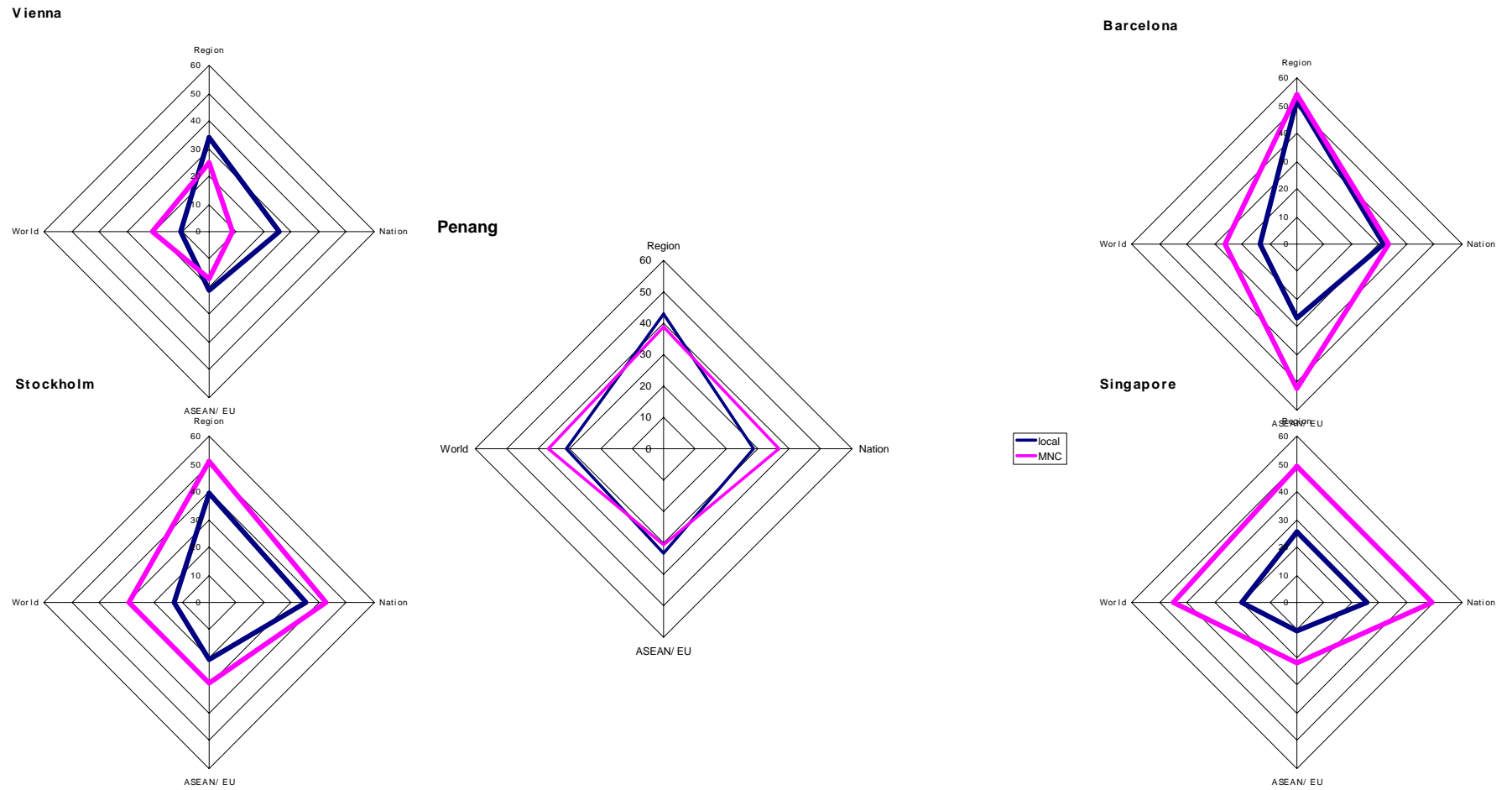
division of labour/ research, which is also connected to c) intra-firm or intra-global production network-hierarchies, where production sites in South East Asia might not have the autonomy to organise their own external cooperation-relation, but are rather dependent on the Europe, North America or Japan based headquarters or 'network flagships' (Ernst, 2002).

The above described pattern is even more striking when it comes to cooperation with universities or R&D institutes: MNC affiliates in Europe hardly ever cooperate directly with institutions outside Europe. Most contacts in Europe are restricted to the region, which is a sign of the strength of the Metropolitan Innovation systems which offer enough cooperation opportunities to meet the demand of the MNCs. Only the MIS in Vienna seems to be fairly weak, being more attractive for local companies than for multinationals. On the other hand, MNCs in Penang cooperate as often globally as they cooperate regionally, while in Singapore the S&T infrastructure seems to be fairly conducive to cooperation-seeking MNCs.

Nevertheless, MNCs in Singapore do not rely on regional contact solely, but have a very strong focus on institutions in the rest of the world as well.

The strong regional focus of MNC affiliates in Europe is therefore an indicator of the attempt to tap into localized knowledge in order to augment the companies' knowledge base and to feed this knowledge into intra-firm networks.

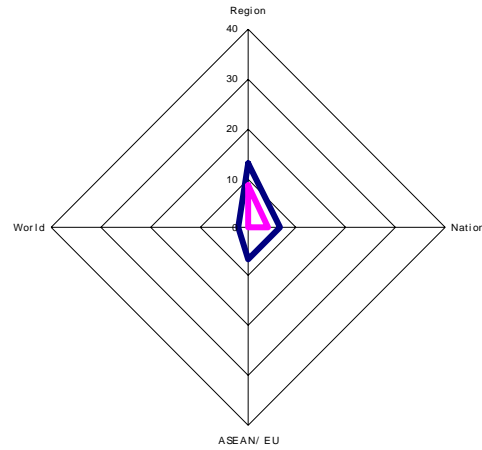
Figure 2. Spatial Distribution of cooperation partners: Any partner



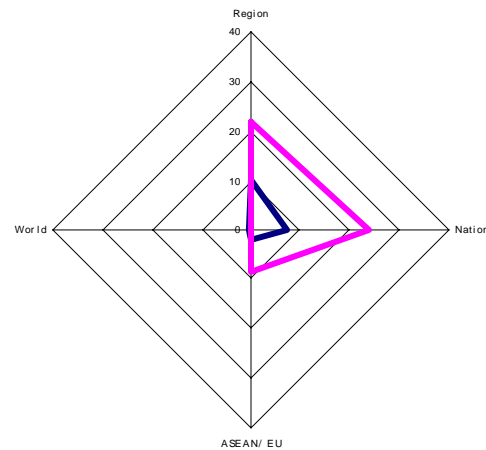
N.B. No spatial information for Thailand has been gathered. In Singapore the data for the national and regional level is the same.

Figure. 3 Spatial Distribution of cooperation partners: Universities and R&D institutes

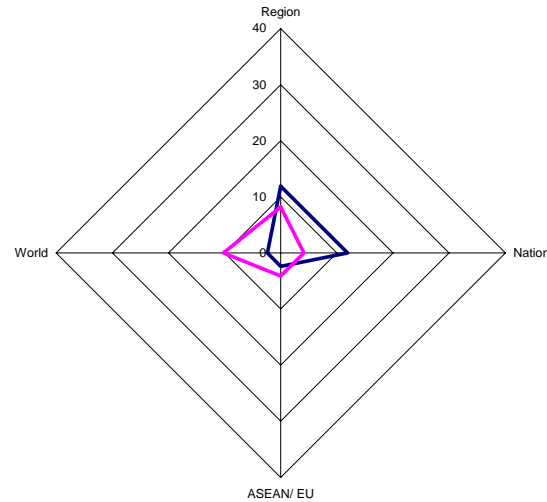
Vienna



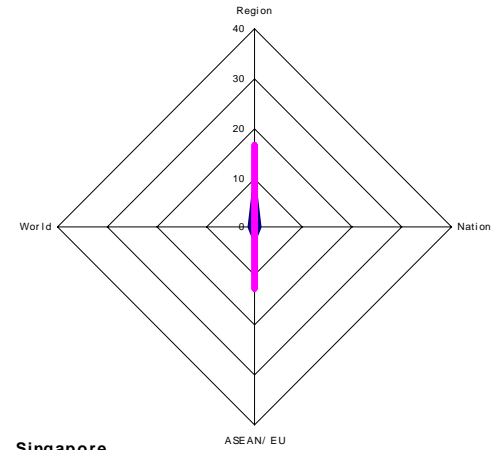
Stockholm



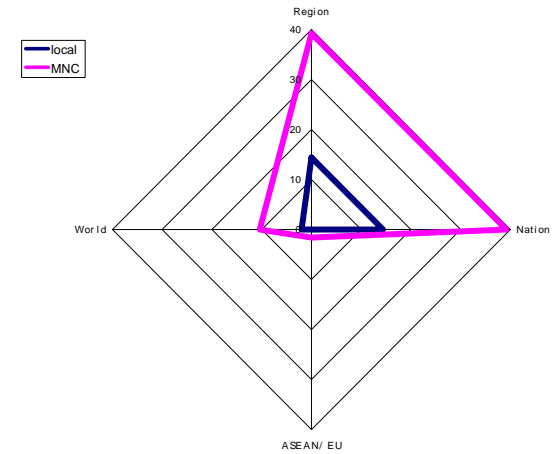
Penang



Barcelona



Singapore



N.B. No spatial information for Thailand has been gathered. In Singapore the data for the national and regional level is the same.

Table 9 depicts only the cooperation behaviour within the MIS. Again, the Asian regions show a generally higher share of cooperating companies. Remarkably, a significantly higher share of local firms in the Asian regions cooperates with customers within the MIS. Since Asian local companies are less export oriented than their European counterparts, this indicates that they frequently supply locally based (multinational) customers, with whom they cooperate when it comes to innovation. MNCs on the other hand are less likely to co-operate with customers in the Asian metropolises, due to their embeddedness into the corporate network and their orientation towards the global market (see also Kiese, 2004).

Moreover, MNCs in Singapore cooperate significantly more often with research institutes or universities in Singapore. This documents the strength of the scientific infrastructure, which was improved markedly in the 1990s by the establishment of thirteen new public research institutes and the significant expansion of R&D activities at the tertiary institutions (Wong, 2001; Kiese, 2004).

The European MIS show similar levels of cooperation, with Vienna being fairly weak in customer and supplier linkages, while especially Barcelona-based MNCs frequently cooperate with suppliers from within the MIS. Additionally, in Stockholm and Barcelona MNCs are clearly but not significantly more often involved in co-operations with research institutes and universities.

Table 9. Share (%) of innovating companies that collaborate with at least one of the following partners within the Metropolitan Innovation System

Region	Customer	Supplier	Service Provider	Research Institution/ University	Other company/ Competitor
Europe					
Barcelona (n=142)	33.1	28.9	30.3	11.3	7.0
- Local Firm	35.0	25.8	29.2	9.2	5.8
- MNC	22.7	45.5	36.4	22.7	13.6
<i>Significance</i> *	<i>0.261</i>	<i>0.062</i>	<i>0.499</i>	<i>0.076[#]</i>	<i>0.187[#]</i>
Stockholm (n=169)	33.1	12.4	21.3	18.3	6.5
- Local Firm	33.3	9.8	21.1	15.4	8.1

- MNC	32.6	19.6	21.7	26.1	2.2
<i>Significance</i> *	0.929	0.085	0.932	0.112	0.292 [#]
Vienna (n=62)	16.1	4.8	21.0	12.9	6.5
- Local Firm	12.5	2.5	22.5	15.0	7.5
- MNC	22.7	9.1	18.2	9.1	4.5
<i>Significance</i> *	0.307 [#]	0.285 [#]	0.756 [#]	0.700 [#]	1.000 [#]
South-East Asia					
Singapore (n=103)	65.0	59.2	52.4	67.0	21.4
- Local Firm	79.5	59.0	43.6	51.3	28.2
- MNC	56.3	59.4	57.8	76.6	17.2
<i>Significance</i> *	0.016	0.968	0.161	0.008	0.186
Penang (n=42)	57.1	59.5	35.7	21.4	28.6
- Local Firm	73.7	52.6	47.4	26.3	36.8
- MNC	43.5	65.2	26.1	17.4	21.7
<i>Significance</i> *	0.049	0.408	0.152	0.707 [#]	0.281

N.B. The Thailand R&D/ Innovation Survey does not include questions about the spatial distribution of cooperation partners

* Asymptotic Significance according to Pearsons's Chi- Square Test, two- sided

[#] Exact Significance according to Fisher's Exact Test, two-sided (used if at least one cell with expected frequency <5)

Conclusion

In recent years there has been an increase in the internationalisation of R&D facilities.

Mainly, R&D units follow existing production plants abroad. But besides this kind of home-base-exploitation R&D activities, an increasing number of MNCs also invest in home-base-augmenting facilities, which have the objective of enhancing the existing knowledge stock of the multinational corporation. In order to achieve this goal they try to tap into localized and specialised pools of knowledge in different locations, and therefore there is a strong interaction between regional or metropolitan innovation systems, which can mutually benefit each other. MNCs can make use of localised knowledge networks, and these networks become stronger and gain access to international knowledge by incorporating MNCs.

Based on these theoretical arguments, we started to enquire into two hypotheses:

1) The traditional spatial pattern of R&D activity suggests that MNCs would perform much more R&D in Europe than in South-East Asia. Is this picture still valid for successful latecomers like Singapore vis-à-vis European Metropolitan Regions?

There is overwhelming evidence that the majority of innovation activity in the six case regions is still being performed in Europe. Despite favourable secondary data for Singapore, the analysis of the micro-level data pointed towards a considerable gap between the innovation potential and performance in Singapore and the European regions. While Penang is doing fairly well, and clearly better than the nationwide secondary statistics indicated, Bangkok is lagging significantly behind, as is Thailand as a whole. For the Thai case, it might be even argued, that the mismatch between the development level of the economic structure and the NIS contributed significantly to the 1997 Asian crisis, in which the Thai economy “slumped more seriously” and “the economic recovery has been much slower” than in the east Asian NIEs (Intarakumnerd et al., 2002: pp. 1452).

2) Is there evidence to support the hypothesis that MNCs in Europe tend to be more involved in HBA, while MNC in South East Asia are more orientated towards HBE?

To sum up the evidence in favour of this hypothesis: MNCs in Europe are more orientated towards product innovation, while MNCs in South-East Asia are more likely to conduct process innovations. MNCs in Europe devote significantly more resources in terms of R&D expenditure and personnel to their innovation activities than local companies. The picture in South-East Asia is just the opposite. Even though Kuemmerle (1999: 9) concluded that “HBA and HBE FDI in R&D require similar resource commitments”, we see the difference in the commitment to the innovation process as an indication of different types of R&D units. Additional support for this assessment is provided by the spatial distribution of cooperation partners: innovating MNC affiliates in Europe cooperate more often with regional partners and less often directly with partners in the rest of the world. On the other hand, MNC subsidiaries in Singapore and Penang are much more outward looking, indicating structural weaknesses in the Metropolitan Innovation System that have to be overcome by international contacts. Especially, MNCs in Europe are more likely to cooperate with universities and R&D institutes within their host region. This is true of MNCs in Singapore as well, but again, the

global orientation in Singapore is much stronger, giving evidence of an insufficient S&T infrastructure as well as a stronger hierarchical dependence in Singapore. The same can be observed in Penang. Together with the assessment of the availability of suitable human capital, this points towards more HBA orientated R&D activities in Europe, and this is in line with Kuemmerle's findings that "a firm's propensity to invest in HBA R&D activities abroad rises with the relative commitment to R&D of private and public entities in the target country, as well as with the quality of the human resource pool and with the level of scientific achievement in relevant sciences" (ibid.: 18). Therefore it also indicates a higher HBA-focus of MNC affiliates in Europe.

What are the political implications of these findings? The regions in South East Asia have to further develop their MIS if they want to maintain their international competitiveness and their position in the global production networks of MNCs vis-à-vis strong competition from other newly industrialising countries and if they want to upgrade from locations for HBE to HBA oriented activities. Therefore investment in basic and applied science infrastructure and the education of human capital has to be a priority. Furthermore, political support for the development of local technology oriented and highly capable companies and start-ups ('technopreneurship') is necessary in order to improve to quality of the MIS and in order to avoid further dependence on international investment, which can pose a substantial threat for sustainable growth as was displayed by the 1997 financial crises.

References

- Alpha Research, 2003 *Thailand in Figures 2002-2003* (Bangkok)
- Amin A, 2000 *Organisational Learning Through Communities of Practice* Paper presented at the Workshop on The Firm in Economic Geography, University of Portsmouth, 9-11 March
- Anselin L, Varga A, Ács Z J, 1997, "Local geographical spillovers between university research and high technology innovations" *Journal of urban economics* **42** 3 422-448
- Archibugi D, Mitchie J, 1995, "The globalization of technology: a new taxonomy" *Cambridge Journal of Economics* **19** 121-140
- BMBF, 2000 *Zur technologischen Leistungsfähigkeit Deutschlands. Zusammenfassender Endbericht*, Bundesministerium für Bildung und Forschung, Bonn
- Braczyk H-J, Cooke P N, Heidenreich M, 1998 *Regional innovation systems : the role of governances in a globalized world* (UCL Press, London [u.a.])
- Brooker Group, 2001 *Technological Innovation of Industrial Enterprises in Thailand - Innovation and R&D in Thailand's Private Sector Information and New Findings*, National Science and Technology Development Agency, Bangkok
- Brouwer E, Budil-Nadvornika H, Kleinknecht A, 1999, "Are urban agglomerations a better breeding place for product innovation? : An analysis of new product announcements" *Regional Studies* **33** 6 541-549
- Bunnell T G, Coe N M, 2001, "Spaces and scales of innovation" *Progress in Human Geography* **25** 4 569-589
- Camagni R, 1991 *Innovation networks: spatial perspectives* (Belhaven Press, London [u.a.])
- Cantwell J, Iammarino S, 2003 *Multinational corporations and European regional systems of innovation* Studies in global competition ; 18 (Routledge, London [u.a.])
- Chandler A D, 1992, "Organizational Capabilities and the Economic History of the Industrial Enterprise" *Journal of Economic Perspectives* **6** 79-100
- Colombo M G, 1995, "Firm size and cooperation : the determinants of cooperative agreements in information technology industries" *International journal of the economics of business* **2** 1 3-29
- Cooke P, 2002 *Knowledge Economies. Clusters, learning and cooperative advantage* (Routledge, London and New York)
- Cooke P, Morgan K, 1998 *The associational economy : firms, regions, and innovation* (Oxford Univ. Press, Oxford [u.a.])
- Crevoisier O, 1998, "Innovation and the city", in *Making connections - technological learning and regional economic change* Eds E J Malecki and P Oinas (Ashgate, Aldershot [u.a.])
- Dunning J H, 1998, "Location and the multinational enterprise : a neglected factor?" *Journal of international business studies* **29** 1 45-66
- Dunning J H, 2000, "Regions, globalization and the knowledge-based economy: the issues stated", in *Regions, Globalization, and the Knowledge Based Economy* Ed J H Dunning (Oxford Univ. Press, Oxford) pp. 8-41
- EC, 2002 *Key figures 2002 : towards a European research area ; science, technology and innovation* (Brussels)
- Edquist C, 1997 *Systems of innovation : technologies, institutions, and organizations* Science, technology and the international political economy series (Pinter, London [u.a.])
- Ernst D, 2002, "Global Production Networks and the Changing Geography of Innovation systems. Implications for Developing Countries" *Economics of Innovation and New Technology* **11** 6 497-523
- Ewers H-J, Wettmann R, 1980, "Innovation-oriented regional policy" *Regional Studies* **14** 161-179

- Feldman M P, Audretsch D B, 1999, "Innovation in cities : science-based diversity, specialization and localized competition" *European economic review : EER* **43** 2 409-429
- Fischer M M, Revilla Diez J, Snickars F, 2001 *Metropolitan innovation systems : theory and evidence from three metropolitan regions in Europe* Advances in spatial science (Springer, Berlin [u. a.])
- Freeman C, Soete L L G, 1997 *The economics of industrial innovation* (Pinter, London [u.a.])
- Fritsch M, Koschatzky K, Schätzl L, Sternberg R, 1998, "Regionale Innovationspotentiale und innovative Netzwerke" *Raumforschung und Raumordnung* **56** 4 243-252
- Fröbel F, Heinrichs J, Kreye O, 1980 *The new international division of labour : structural unemployment in industrialised countries and industrialisation in developing countries* Studies in modern capitalism = Etudes sur le capitalisme moderne (Cambridge Univ. Press, Cambridge [u.a.])
- Gertler M S, 1995, ""Being There": Proximity, Organization, and Culture in the Development and Adoption of Advanced Manufacturing Technologies" *Economic Geography* **71** 1 1-26
- Gertler M S, 2001, "Best practice? Geography, learning and the institutional limits to strong convergence" *Journal of Economic Geography* **1** 1 5-26
- Ghoshal S, Barlett C A, 1990, "Innovation processes in multinational corporations" *Strategic Management Journal* **11** 499-518
- Henderson J, Dicken P, Hess M, Coe N, Yeung H W-c, 2002, "Global production networks and the analysis of economic development" *Review of international political economy* **9** 3 436-464
- Hobday M, 1995 *Innovation in East Asia : the challenge to Japan* (Elgar, Aldershot [u.a.])
- Hobday M, 2000, "East versus Southeast Asia innovation systems : comparing OEM- and TNC-led growth in electronics", in *Technology, Learning, & Innovation - Experiences of Newly Industrializing Economies* Eds L Kim and R R Nelson (Cambridge University Press, Cambridge) pp. 129-169
- Hotz-Hart B, 2000, "Innovation Networks, Regions, and Globalization", in *The Oxford handbook of economic geography* Eds G L Clark, M P Feldman and M S Gertler (Oxford University Press, Oxford, England ; New York) pp. 432-450
- Howells J, 1983, "Filter-down theory: Location and technology in the UK pharmaceutical industry" *Environment and Planning A* **15** 147-164
- Hudson R, 1999, ""The learning economy, the learning firm and the learning region": A sympathetic critique of the limits to learning" *European Urban and Regional Studies* **6** 59-72
- IMD, 1998 *The world competitiveness yearbook 1998* (International Institute for Management Development,, Lausanne)
- IMD, 1999 *The world competitiveness yearbook 1999* (International Institute for Management Development,, Lausanne)
- IMD, 2001 *The world competitiveness yearbook 2001* (International Institute for Management Development,, Lausanne)
- IMD, 2003 *The world competitiveness yearbook 2003* (International Institute for Management Development,, Lausanne)
- IMD, 2004 *The world competitiveness yearbook 2004* (International Institute for Management Development,, Lausanne)
- Intarakumnerd P, 2004, *Thailand's National Innovation System in Transition* in, First Asialics International Conference on Innovation Systems and Clusters in Asia: Challenges and Regional Integration(Bangkok)

- Intarakumnerd P, Chairatana P-A, Tangchitpiboon T, 2002, "National innovation system in less successful developing countries: the case of Thailand" *Research Policy* **31** 8-9 1445-1457
- Ivarsson I, 2002, "Transnational corporations and the geographical transfer of localised technology : a multi-industry study of foreign affiliates in Sweden" *Journal of economic geography* **2** 2 221-247
- Ivarsson I, Jonsson T, 2003, "Local technological competence and asset-seeking FDI: an empirical study of manufacturing and wholesale affiliates in Sweden" *International Business Review* **12** 3 369-386
- Kiese M, 2004 *Regionale Innovationspotentiale und innovative Netzwerke in Südostasien : Innovations- und Kooperationsverhalten von Industrieunternehmen in Singapur* Hannoversche geographische Arbeiten ; 56 (Lit, Münster [u.a.])
- Kiese M, Revilla Diez J, 2004, "Regionale Innovationspotentiale in Südostasien - Empirische Ergebnisse aus Singapur, Penang (Malaysia) und Thailand" *Geographica Helvetica* **57** 3
- Kuemmerle W, 1999, "The drivers of foreign direct investment into research and development : an empirical investigation" *Journal of international business studies* **30** 1 1-24
- Lundvall B-Å, 1985 *Product innovation and user-producer interaction* Industrial development research series ; 31 (Univ. Press, Aalborg)
- Lundvall B-Å, 1992 *National systems of Innovation: Towards a Theory of Innovation and Interactive Learning* (Frances Pinter, London)
- Mani S, 2004, *Financing of Innovation - A survey of various institutional mechanisms in the context of two high technology exporting developing economies from Asia* in, First Asia Pacific International Conference on Innovation Systems and Clusters in Asia: Challenges and Regional Integration (Bangkok)
- Maskell P, Eskelinen H, Hannibalsson I, Malmberg A, Vatne E, 1998 *Competitiveness, localised learning and regional development : specialization and prosperity in small open economies* Routledge frontiers of political economy ; 13 (Routledge, London [u.a.])
- Ministry of Education Singapore, 2004, *Education Statistics Digest* Online
- Munier F, 2004 (forthcoming), "Firm Size, Technological intensity of sector and relational competencies to innovate : evidence from french industrial innovating firms" *Economics of Innovation and New Technology* SPECIAL ISSUE of the Economics of Innovation and New Technology - Empirical Studies of Innovation in the Knowledge Driven Economy
- Nelson R R, 1993 *National Innovation Systems: A comparative analysis* (Oxford University Press, New York)
- NSTDA, 1999 *Thailand Science and Technology Profile 1999*, National Science and Technology Development Agency, Bangkok
- OECD, 1998 *Internationalisation of Industrial R&D. Patterns and Trends* (OECD, Paris)
- OECD, 1999 *Benchmarking the knowledge base economy* (OECD, Paris)
- Patel P, Pavitt K, 1998, *National systems of innovation under strain: The internationalisation of corporate R & D* in, Science Policy Research Unit: Electronic Working Papers Series Paper No 22 (Sussex)
- Reddy P, 2000 *The globalization of corporate R&D : implications for innovation systems in host countries* Routledge studies in international business and the world economy ; 18 (Routledge, London [u.a.])
- Revilla Diez J, 2000, "The Importance of Public Research Institutes in Innovative Networks - Empirical Results from the Metropolitan Innovation Systems Barcelona, Stockholm and Vienna" *European Planning Studies* **8** 4 451-463

- Revilla Diez J, 2002a *Betrieblicher Innovationserfolg und räumliche Nähe : zur Bedeutung innovativer Kooperationsverflechtungen in metropolitanen Verdichtungsregionen ; die Beispiele Barcelona, Stockholm und Wien* Wirtschaftsgeographie 22 (Lit, Münster)
- Revilla Diez J, 2002b, "Innovation activities and networks in metropolitan systems of innovation : empirical findings from Barcelona, Vienna and Stockholm", in *Technological change and regional development in Europe* Eds L Schätzl and J Revilla Diez (Springer, Heidelberg, New York)
- Revilla Diez J, 2002c, "Metropolitan innovation systems : a comparison between Barcelona, Stockholm, and Vienna" *International regional science review* 25 1 63-85
- Revilla Diez J, Berger M, 2004, "Technological Capabilities and Innovation in Southeast Asia - Empirical Evidence from Singapore, Penang (Malaysia) and Thailand", in *Innovation and Clusters in Asia* Eds P Intarakumnerd and J Vang (in press)
- Revilla Diez J, Kiese M, 2004, "Scaling Innovation in Southeast Asia: Empirical Evidence from Singapore, Penang (Malaysia) and Bangkok" *Economic Geography* (submitted)
- Schiller D, 2003: *Technologische Leistungsfähigkeit Thailands: Die Rolle der Forschungs- und Technologiepolitik und das regionale Innovationspotenzial im Verarbeitenden Gewerbe* Unpublished Diploma Thesis, Geographisches Institut, Universität Hannover, Hannover
- Shefer D, Frenkel A, 1998, "Local milieu and innovations : some empirical results" *The Annals of Regional Science* 32 1 185-200
- Sternberg R, 2000, "Innovation Networks and Regional Development- Evidence from the European Regional Innovation Survey (ERIS)" *European Planning Studies* 8 4 389-407
- Stichweh R, 1999, "Globalisierung der Wissenschaft und die Region Europa", in *Globalisierung. Ökonomische und soziale Herausforderungen am Ende des zwanzigsten Jahrhunderts. Sonderband 13 der "Sozialen Welt"* Eds G Schmidt and R Trinczek (Nomos, Baden-Baden) pp. 275-292
- Stracke S, 2003: *Technologische Leistungsfähigkeit im Innovationssystem Penang, Malaysia* Unpublished Doctoral Thesis, Abteilung für Wirtschaftsgeographie, Universität Hannover, Hannover
- Suárez-Villa L, Fischer M M, 1995, "Technology, organization and export-driven research and development in Austria's electronics industry" *Regional studies* 29 1 19-42
- UNESCO, 2004, *Science and Technology Statistics*
- Varga A, 1998 *University research and regional innovation : a spatial econometric analysis of academic technology transfers* Economics of science, technology, and innovation ; v. 13 (Kluwer Acad. Publ., Boston [u.a.])
- Virasa T, Brimble P, 2001, *Technological Innovation of Industrial Enterprises in Thailand* in, Regional Workshop on Innovation in the Manufacturing Sector (Penang, The Gurney Hotel)
- Wong P K, 1999, *National Innovation Systems for Rapid Technological Catch-up: An analytical framework and a comparative analysis of Korea, Taiwan and Singapore* in, DRUID Summer Conference on National Innovation Systems, Industrial Dynamics and Innovation Policy (Rebild, Denmark)
- Wong P K, 2001, "Leveraging multinational corporations, fostering technopreneurship : the changing role of S&T policy in Singapore" *International journal of technology management* 22 5/6 539-567