Foreign Subsidiaries in the East German Innovation System – Evidence from manufacturing industries

Abstract

This paper analyses the extent of technological capability of foreign subsidiaries located in East Germany, and looks at the determinants of foreign subsidiaries' technological sourcing behaviour. The theory of international production underlines the importance of strategic and regional level variables. However, existing empirical approaches omit by and large regional level factors. We employ survey evidence from the "FDI micro database" of the IWH, that was only recently made available, to conduct our analyses. We find that foreign subsidiaries are above average technologically active in comparison to the whole East German manufacturing. This can be partially explained by the industrial structure of foreign direct investment. However, only a limited share of foreign subsidiaries with R&D and/or innovation activity source technological knowledge from the East German innovation system. If a subsidiary follows a competence augmenting strategy or does local trade, it is more likely to source technological knowledge locally. The endowment of a region with human capital and a scientific infrastructure has a positive effect too. The findings suggest that foreign subsidiaries in East Germany are only partially linked with the regional innovation system. Policy implications are discussed.

JEL-Classification: O30, O38, F20

Keywords: East Germany, Regional Innovation System, Foreign Direct Investment

1 Introduction

In catching-up regions, policy makers in charge of economic development are active in promoting foreign direct investment (FDI). This is related to the expectation that foreign direct investors built up modern production capability, create new employment, and stimulate demand. Economist as well as policy makers emphasise also the potentials of FDI induced knowledge transfer and spillover effects. In principle, one could argue that such technological effects could derive from any investment without consideration of ownership or origin. However, the particularity of foreign investors in post-transition regions stems from the fact that they often represent globally operating firms with a strong endowment in terms of financial and human resources as well as access to an international network of knowledge creation. The performance of such multinationals has the potential to affect the competitiveness and economic situation of regions within host-countries. In addition, post-transition countries often lack indigenously owned firms that operate internationally through a network of own subsidiaries. Therefore, we tend to see a considerable competition between countries as well as regions with countries for FDI. In order to attract foreign investors and to leverage positive effects, policy makers revert to fiscal incentives, improve local infrastructure, and bolster human capital, as well as science and technology.

FDI has not only been relevant to the transition process in Central and Eastern Europe or Asia, it played also a considerable role in East Germany. Today, firms with foreign equity participation account for about 25 per cent of employment in the whole East German manufacturing industry.[1] During the 1990s the ‘Industrial Investment Council’ (IIC) was created as an agency in charge of promoting East Germany as investment location internationally. This task has also been performed alongside the regional investment agencies (‘Wirtschaftsfördergesellschaften’). In 2007, the German government re-emphasised the importance of inward FDI and bundled the existing competencies and resources through a merger of IIC with Invest in Germany (IIG), which was formerly focusing on West Germany. Thus, FDI remains on the political agenda, and, from our point of view in particular for further economic development in East Germany.

Policy makers as well as economist dealing not only with the attraction of foreign investors but also the upgrading of existing operations to create more sustainable effects from FDI are confronted with a number of questions, such as: How attractive is the region for international investors? Is East Germany primarily home to “extended work benches”, or not? Does FDI by and large constitute modern equipped production sites fully integrated into the international corporation, but isolated from the domestic economy? Or, do foreign subsidiaries engage in own technological activities such as R&D and innovation? Do they exchange knowledge and technology with local partners in the regional innovation system? And finally, which firm and region specific factors

1 Source: FDI micro database and IAB Establishment Panel (see also Annex A1).

influence foreign investors’ decision to locate technological activities in a particular region and to source technology locally?

This paper argues that whether or not foreign direct investment can support economic catching-up in East Germany - inter alia - depends upon their technological capability and the intensity of technological linkage with other actors from the regional innovation system, such as East German based scientific institutions, suppliers, or customers. From the theory of international production (Cantwell and Iammarino 1998, 2003, etc.) and the international management literature (von Zedtwitz and Gassman 2002, Andersson et al 2002, etc.), it is well known that the strategy followed by a foreign investor depends not only on internal considerations, but also on the locational factors that the host economy is endowed with. However, the regional variables have only been implemented in existing empirical studies to a limited extent (Almeida 1996, Criscuelo et al 2002, Frost 2001). In addition, existing approaches (ibid.) do not discriminate between different sources for technological knowledge within the host country. Against this background, the objective of this paper is twofold: First to assess the scope of technological capability in foreign subsidiaries located in East Germany, and second, to investigate the factors that determine foreign subsidiaries technology sourcing from the selected actors of the East German innovation system.

This empirical analysis is based on the newly created “FDI micro database” of the IWH that holds the total population of manufacturing firms with foreign ownership based in East Germany (Neue Länder including Berlin). This unique database formed the basis for a representative survey of foreign subsidiaries that was completed in Spring 2007. The database provides a rich dataset on internationally accepted technological indicators as well as a number of organisational variables that are not available in other existing datasets for East Germany.

The paper starts with a theoretical overview of the organisation of technological activities in international firms, followed by several hypotheses with regard to the determinants of foreign subsidiaries technology sourcing from a regional innovation network. This leads to a description of the “FDI micro database” and the survey evidence used in the subsequent empirical analysis. The next section offers a comparative assessment of technological capability of foreign subsidiaries in East Germany. Finally, we test our hypotheses with regard to the determinants of foreign subsidiaries technology sourcing in the framework of an ordered probit estimation. The article continues with a discussion or the corresponding results and concludes with a section on policy implications.

2 Theory and Hypotheses Development

From an organisational perspective, the locus of technological innovation resides not only within the boundaries of the firm, but also outside, at the interfaces between firms, universities, research laboratories, suppliers, and customers (Powell et al. 1996). Many innovations intrinsically require collective efforts, involving different stakeholders to act cooperatively to generate new knowledge and ideas (Chesbrough 2003). This point of view is related to the idea that innovation proceeds by the recombination of existing knowledge (Kogut and Zander 1992, Nonaka 1994). The use of multiple sources for technological knowledge leads both, to increases in technological opportunity (Klevorick et al. 1995) as well as complementarities and synergies between knowledge sources (Leiponen and Helfat 2004). For example, academic research provides knowledge central to industrial innovative activity, yet it generally does not provide solutions to the more applied sort of problems on which firms tend to focus on (Mansfield 1991, Pavitt 1998). Agreements between firms tend to focus more on product-specific developments of basic research discoveries (Arora and Gambardella 1990). Users i.e. firms or individual consumers that expect to benefit from using a product, are potentially able to provide knowledge regarding problems with, or desired modifications of existing products (von Hippel 1976, 2005). Suppliers provide producers with knowledge regarding inputs, including raw materials, plants and equipment, product components, and subsystems relevant to technological processes.

What does this mean for technological processes in foreign subsidiaries of internationalised firms? It has been suggested that the traditional advantages of centralisation of R&D and innovation activities in home economies – often connected to economies of scale and scope in R&D – seem to be increasingly counterbalanced by those advantages associated with decentralisation of technological activities (Pearce and Singh 1992, Howells and Wood 1993, Miller 1994). Decentralisation offers linkages between technological activity and foreign production, local markets, suppliers and clients, and the exploitation of technological fields of excellence in host economies of subsidiaries (Dunning and Wymb 1999, von Zedtwitz and Gassman 2002, Cantwell and Iammarino 2003, Cantwell 1992, 1993). However, firms have not internationalised their innovative activity proportionally to the growth in their overall production activities (Zanfei 2000, Patel and Pavitt 1999). This could be associated – inter alia – with the complex nature of systems of innovation, and the embeddedness of the firms' technological activities in the home environment (Narula 2002), and the need for internal cohesion within the firm (Blanc and Sierra 1999, Zanfei 2000).

Overseas technological activities, on the one hand, can be associated with adapting and modifying firms' existing technological assets in response to demand conditions. This has been labelled as 'home-base exploiting' (Kuemmerle 1997) or 'competence exploiting' behaviour (Cantwell and Piscitello 1999, Cantwell and Mudambi 2005). On the other hand, foreign subsidiaries can be used to augment existing technological assets by actively absorbing technological spillovers, either from the local knowledge base in general (public infrastructure or to benefit from agglomerative effects in a specific sector), or from specific firms in particular (see e.g., Dunning and Narula 1995, Cantwell and Janne 1999, Patel and Vega 1999). This strategy has been labelled as 'home-base augmenting' (Kuemmerle 1997), or 'competence augmenting' (Cantwell and Piscitello 1999, Cantwell and Mudambi 2005). Criscuelo et al. (2002) hold that most foreign firms simultaneously engage in both, competence exploiting and competence augmenting activities, because products are multi-technology based, and therefore, any given subsidiary has a need for a variety of technologies, and any given host location may possess a relative technological advantage in one area but not in another.

Importantly, subsidiaries' capacity to exploit or augment technological competences is a function not only of its own resources, but also the capability to utilise complementary resources associated with the relevant local innovation system (Criscuelo et al. 2002). Almeida (1996) reveals that the technological sourcing of foreign owned firms in the US semiconductor industry is regionally concentrated and focused on particular firm-to-firm linkages. Owing to the complexity of technological learning, and the significance of maintaining face-to-face contacts the technological sourcing of foreign subsidiaries tends to be regionally (Almeida 1996, Cantwell and Iammarino 1998). Therefore, it seems appropriate to analyse foreign firms' technology sourcing at the sub-national level in the context of a regional innovation system[2] (see Cantwell and Iammarino 1998, 2003).

The existing theory on the question under what conditions foreign subsidiaries draw on local knowledge sources is still fairly limited (Frost 2001, Criscuelo et al. 2002). Criscuelo et al. (2002) state that home base augmenting activities are primarily undertaken with the intention to acquire and internalise technological spillovers that are location-specific in the host economy. This objective is secondary for competence exploiting subsidiaries. Similarly, Frost (2001) argues that an exploitive strategy reinforces the existing knowledge base of the corporation through reproduction and incremental extension. The focus on refinement and adaptation is more likely to preserve the existing search routines of the whole corporation, which are strongly associated by internal knowledge flows and the parent firm's existing external network in the home country. In contrast, with an augmenting strategy the scope of subsidiaries' search may be broadened, and it is more likely to incorporate resources that lie outside of the existing network of the parent company (ibid). Both authors provide sufficient ground to hypothesise that:

> *H(1) A foreign subsidiary following a competence augmenting strategy, is more likely to source technological knowledge from the regional innovation system.*

The primary function of subsidiaries with competence-exploiting mandates is to serve the local market. Their role is predominantly demand-driven. Thus, Frost (2001) argues that a home-base exploiting innovation strategy that adapts foreign parent technological base of the foreign subsidiary has a negative effect on subsidiaries' external technology sourcing from the host country environment. Therefore, we hypothesise:

2 A regional innovation system can be defined as a network of regionally interacting actors and institutions from the private and public sector that generate, modify, and diffuse new technologies (Cooke et al. 1997).

H(2) A foreign subsidiary following a competence exploiting strategy, is less likely to source technological knowledge from the regional innovation system.

Still, Cantwell and Mudambi (2005) state that a local market orientation could entail customisation of product and process technology to local market needs. Thus, the higher the level of local demand the higher the incentive to undertake process improvements as well as to differentiate output (ibid). Both of these activities could be associated with increased technological activity of foreign subsidiaries including technological sourcing from local customers. Therefore, we hypothesise that:

H(3) The higher the share of local sales of a foreign subsidiary, the more the foreign subsidiary is likely to source technological knowledge from local customers.

Although, this has not been tested empirically so far, it seems to us that there is no reason why the same rationale should not apply to local suppliers. In other words, foreign subsidiaries could benefit from technological spillovers through backward vertical linkages, because the benefits from vertical technology transfer are assumed to be mutually (Hoekman and Javorcik Smarzinska 2006, Giroud 2007). Thus, we hypothesise that:

H(4) The higher the share of local supplies of a foreign subsidiary, the more the foreign subsidiary is likely to source technological knowledge from local suppliers.

The literature on subsidiary roles and embeddedness suggests that the greater the extent of subsidiary autonomy, the better the ability of the subsidiary to form external network linkages with other companies and institutions in its own local environment (Birkinshaw et al. 1998, Andersson and Forsgren 2000). It is reasonable to suppose that most strategically independent subsidiaries cooperate with other units of the international firm, and so utilise their autonomy as a means of leveraging local technological assets to enhance the competitive advantages of their enterprise group as a whole (Andersson, Forsgren, and Holm, 2002, Cantwell and Mudambi 2005). Therefore, we hypothesise

H(5) The higher the autonomy of a foreign subsidiary, the more likely it is to source technological knowledge from the regional innovation system.

Frost (2001) argues that older foreign subsidiaries, i.e. those with more time and resources to gain a reputation for cooperative behaviour, are more likely to have access to local sources of knowledge than their younger counterparts, which might suffer from the 'liability of newness' (Stinchcombe 1965, Venkataraman and Van de Ven 1998) in the host country environment. Therefore, we hypothesise that:

H(6) The longer the foreign subsidiary is established, the more likely it is to source technological knowledge from the regional innovation system.

Criscuelo et al. (2002) argues that one of the limitations of existing studies on the determinants of local technological sourcing of foreign subsidiaries is the absence of variables for exogenous regional endowment. Fagerberg et al. (1994) suggest that a regions' capacity to adapt and implement new external knowledge determines the degree of attractiveness and the amount of technological spillovers it is able to draw. Research on the relative attractiveness of regions for foreign firms' technological activity has shown a positive impact of local market size, scientific and educational infrastructure, and the potential for intra- and inter-industry spillovers (Jaffe and Trajtenberg 1996, Cantwell et al. 2001, Cantwell and Piscitello 2002). From our point of view there seems sufficient reason to argue that regional endowment does, not only impact on foreign investors' location decision for technological activities, but also on the decision to which extent knowledge or technology is sourced locally. For example, if the region provides a highly skilled work force the subsidiary can directly tap into these human resources, but they also exist in other firms and the public sector, which constitute potential sources of technological knowledge for the foreign subsidiary. Therefore, we hypothesise:

> *H(7.1) The higher the human capital endowment with the region, the more likely the foreign subsidiary is to source technological knowledge from the regional innovation system.*

In a similar way, the foreign firm could be more inclined to source technological knowledge in regions where expenditures for the scientific infrastructure are intensive. This could directly affect technological sourcing from scientific institutions, but also indirectly the capability of other firms, who benefit from such an infrastructure too. Therefore, we hypothesise:

> *H(7.2) The better the scientific infrastructure within the region, the more likely the foreign subsidiary is to source technological knowledge from the regional innovation system.*

Furthermore, the foreign firm could source technological knowledge more intensively, if a region is endowed with an adequate technological knowledge stock. This would indicate that the region is or has been able to generate technological knowledge, which increases the capabilities of potential sources for technological knowledge in the private and public sector. Therefore, we hypothesise:

> *H(7.3) The higher the knowledge stock within the region, the more likely is the foreign subsidiary to source technological knowledge from the regional innovation system.*

The agglomeration effects due to the density of vertically and horizontally linked firms (Marshall 1962, Krugman 1996) could also be related to foreign subsidiaries' technology sourcing, because geographic proximity enhances formal and informal exchange. This applies in particular to inter-firm relationships. It might also be argued that scientific infrastructure reacts in terms of research output to a certain agglomeration of industrial activity within the region. Therefore, we hypothesise:

H(7.4) The higher the industrial agglomeration, the more likely the foreign subsidiary is to source technological knowledge from the regional innovation system.

Finally, Frost (2001) proposes that the greater the innovation activity of a foreign subsidiary, the greater the likelihood that its innovations will draw upon technical ideas originating in the host country. However, there are also studies arguing that the reverse is true, i.e. the existence of local external innovation networks fosters foreign subsidiaries' technological capability (Holm and Fratocchi 1998, Birkinshaw and Ridderstrale 1999) and innovation activity (Pearce and Papanastassiou 1999, Andersson et al. 2002, Yamin and Otto 2004). There seems to be an unresolved issue in the literature with regard to the question whether the causality runs from subsidiaries' technological capability (R&D and innovation) to external technological sourcing or vice versa. We decided, therefore, not to include any hypotheses related to the impact of subsidiaries' R&D or innovation intensity on external technology sourcing in local innovation systems at this stage of the analysis.

In sum, we would conclude that foreign firms' decision to source external technological knowledge is not random. Existing evidence based on patent citation analysis showed that technological sourcing of foreign subsidiaries is regionally concentrated and influenced by various foreign parent and subsidiary level factors. However, current empirical studies do not differentiate between different actors in the innovation system of the host country/region and did not take account for regional endowment factors.

3 The Empirical Analysis of Foreign Subsidiaries in East Germany

3.1 Data

In principle, there exist three data sources for the analysis of foreign subsidiaries in Germany. First, the Federal Bank of Germany (Deutsche Bundesbank) registers foreign direct investment (FDI) in German firms with a balance sheet over three million Euro. The Bundesbank registers FDI for the purpose of balance of payments statistics. Thus the foreign investment is counted only at the firm's principle office in Germany as a whole, without being subdivided according to the local business units a firm possibly has at different locations in Germany. This leads to a systematic distortion of regional FDI data and a severe underestimation of foreign investment in East Germany (Günther 2005, Votteler 2001). Thus, the FDI data of the Deutsche Bundesbank is not suitable for analyses of East German foreign subsidiaries.[3] Furthermore, the Mannheim Innovation Panel (MIP), which is the German contribution to the Community Innovation Survey (CIS), as well as the IAB establishment panel offer firm level data including information about foreign ownership and innovation activities. Both datasets are representative only for the East German economy as a whole, however not for the subgroup of foreign investors within East Germany. This is due to the fact that sample selection criteria of these data sets are industries, firm size classes and location (East, West Germany), but not ownership structure. Apart from the problem of representativeness, specific indicators relevant for the subject of our paper are not subject to the existing data sets, such as the importance of local actors of the East German innovation system.

Due to these restrictions, our empirical analysis is based on own data collection with the intention to generate firm specific, representative data on foreign subsidiaries in East Germany. Before running the survey, the total population of foreign subsidiaries in East Germany had to be identified. It is defined as all manufacturing firms located in East Germany (including Berlin) with a foreign equity share of at least 10 per cent.[4] The total population in this sense is not generally available. Therefore, we had to build the total population including at least information on the companies' name, address, industry, number of employees and ownership status. In order to realize this, we used four existing company databases, namely Markus, European Investment Monitor, R&D Scoreboard[5], and a list of investment projects in East Germany compiled by the Industrial Investment Council (IIC) dating back to the privatisation period[6]. From these sources, 1 090 valid manufacturing companies were identified as total population in the year 2006. For each subsidiary information on the name, address, industry, number of employees, and origin of the investor is available. Thus, the total population as such is already an asset since it is the first database for East Germany that allows reliable insights on the regional and sectoral distribution, the origin and employment of all foreign subsidiaries in East Germany etc.

In order to "verify" the size of the total population (1 090) we compare with other data sources: The German Bundesbank identifies only 360 companies with foreign participation in the East German manufacturing industry (including Berlin) in 2006. This severe underestimation is due to the aforementioned registration procedures of the

3 A prominent example is the automobile manufacturer Opel, a 100% foreign owned subsidiary of General Motors (GM). The Bundesbank registers the foreign participation only at the principal office of Opel in Rüsselsheim (Hessen). Other local business units, such as in Bochum (North Rhine Westphalia) or in Eisenach (Thüringen) cannot be counted separately in the Bundesbank statistics.

4 Foreign owner or shareholder can be a person, an industrial firm, a financial investors, or a foundation abroad.

5 Source: EC (2006) Monitoring Industrial Research: Analysis of the 2005 EU Industrial R&D Investment Scoreboard. Sevilla.

6 IIC was the East German investment promotion agency, which in 2007 merged with Invest in Germany (IIG).

Bundesbank. The IAB establishment panel, in the year 2005, surveyed 127 companies with majority foreign ownership (here defined as foreign participation of at least 50 per cent) in the East German manufacturing industry and estimates its total population to be 828 (using weightening factors).

Table 1:
Comparison of the Total Population and the Sample by Size Classes and Industries – Share of Foreign Subsidiaries in % -

	Total population	Sample
Size classes (number of employees)		
1 to 9	17,8	14,4
10 to 49	28,7	32,9
50 to 249	37,2	40,0
above 249	16,3	12,6
Industries (NACE 2-digit)		
Food	6,6	6,8
Tobacco	0,3	0,0
Textile	2,5	3,6
Clothes	0,4	0,9
Leather products	0,2	0,5
Wood and wood products	2,6	3,6
Paper and paper products	3,5	4,1
Publishing and printing	4,1	3,6
Coke, refined petroleum products	0,6	0,9
Chemical industry	8,3	12,6
Rubber and plastic	5,6	3,2
Non-metallic mineral products	8,8	10,4
Basic metals	3,5	5,4
Fabricated metal products	10,3	8,6
Machinery	10,0	10,8
Office equipment	2,1	0,5
Electrical equipment	4,8	2,3
Telecommunication	5,6	6,3
Optical equipment	7,4	4,5
Motor vehicles	4,7	2,7
Other vehicles	2,7	2,3
Other manufacturing n.e.c.	3,4	4,5
Recycling	1,6	2,3

Source: FDI micro database of the IWH, own calculations.

All foreign subsidiaries of the total population have been included in a survey carried out in winter 2006/2007 via computer assisted telephone interviews (CATI). Interview partners have been the firms’ general director and/or the head of the R&D department.[7] Data has been collected on general firm characteristics, on technological indicators (R&D, innovation), autonomy in business functions as well as information on the importance that foreign subsidiaries’ assign to potential external partners.[8] Finally, 222 complete interviews could be carried out which means a rate of return of 20.4 per cent.

According to chi-square tests, the sample (222) is representative at the level of size classes, industries (NACE 2-digit), and regions (Raumordnungsregionen). That means, with respect to these indicators the distribution in the sample is not significantly different form the distribution in the total population. Table 1 compares the total population and the sample with respect to size classes and industries.

The resulting sample of foreign subsidiaries is the first representative dataset that allows detailed structural, technological, and governance analyses of foreign investors in the East German manufacturing industry. It forms part of the “FDI micro database” of the IWH which includes the same information on foreign subsidiaries in selected Central East European countries too (Croatia, Estonia, Poland, Slovenia, and Romania). So far, data collection was conducted in one wave. The resulting cross-sectional database does however contain some lagged variables, where questions were asked for the situation in 2002 and 2005 (e.g. sales, employment, R&D).

In the following empirical analyses, we draw on the survey data in order to investigate foreign subsidiaries behaviour in the East German innovation system. In the descriptive analysis of foreign subsidiaries’ technological capability we also draw on some additional data sources in order to provide comparative figures for the whole East German manufacturing industry.[9]

3.2 Stylised Facts: Technological Capability of Foreign Subsidiaries in East Germany

Before turning to technological indicators, we provide some structural information on foreign subsidiaries in East Germany including data on sectoral specialization.

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7 The interviews have been carried out through the Zentrum für Sozialforschung Halle (ZSH) at the Martin-Luther-University Halle-Wittenberg. The ZSH has specialized in the implementation of CATI and the institute has a rich experience in the collection of company data in East Germany. Interviewers have been trained by members of the IWH project team.

8 All technological indicators (innovation, R&D) have been collected according to the international guidelines of the Oslo- and Frascati-Manual.

9 Figures from the IAB establishment panel are based on own calculations (using weightening factors), Eastern part of Berlin is included. Euronorm figures stem from the R&D survey regularly conducted by Euronorm in the East Germany economy including Berlin (Euronorm 2007). Comparative data from the Mannheim Innovation Panel (MIP) is taken from “Indikatorenbericht zur Innovationserhebung 2006” (ZEW 2007). MIP data for manufacturing industry includes mining & quarrying, Berlin is included.

According to the "FDI micro database", firms with foreign equity participation of at least 10 per cent account for 3 per cent of the total number of East German manufacturing firms, but about 25 per cent of total employment (see Annex Table A1).

With respect to the sectoral specialization of foreign subsidiaries we have already some information from the total population (see Table 1). In the total population of foreign subsidiaries, most firms belong to "metal processing", "machinery", "non-metallic mineral products" (together 29 per cent). However, this does only account for the number of firms. If we look at the share of employment over total employment in foreign firms, the top-3 industries are "electrical industry" (20%), "chemical industry" (17%), and "food and tobaco" (11%) – the first two clearly belonging to technologically advanced industries. In the total East German manufacturing industry this is different. Here, the three most important industries are "machinery" (16%), "food and tobaco" (15%), and "office and optical equipment" (12%).[10]

Table 2
Share of Foreign Subsidiaries with Innovation (2002-2005) and R&D Activity (2005) in the East German Manufacturing Industry

	Share (% of total)	n
Product innovation (2002-2005)	69	153
Process innovation (2002-2005)	69	153
Product or process innovation (2002-2005)	79	176
R&D expenditures (2005)	60	132
Product or process innovation or R&D	82	182

Note: Product innovation: new or significantly improved good or service, new to the firm or new to the market. Process innovation: introduction of a new or significantly improved production process.

Source: FDI micro database of the IWH, own calculations.

Research & Development (R&D) is a central technological activity, often (but not always) the prerequisite for product or process innovation. Regarding the R&D performance of foreign subsidiaries, our survey data shows that 60 per cent of firms conducted own R&D at their East German location in the year 2005 (see Table 2). Compared to the whole East German manufacturing industry, this is a very high proportion. According to the IAB establishment panel, only 12 per cent of all manufacturing firms in East Germany reported own R&D activity in 2004 (latest figure available). In contrast, R&D intensity (R&D expenditure in per cent of turnover) stands only at 3 per cent for the foreign subsidiaries. This is clearly below the 8 per cent observed for the total East German manufacturing industry (the latter figure: Euronorm 2007). The picture is very similar if we measure R&D intensity as the share of R&D personnel in per cent of total employees. Here foreign subsidiaries stand at 7 per cent versus 13 per cent for the total East German manufacturing industry (the latter figure: Euronorm 2007). The comparatively low R&D intensity of foreign subsidiaries can at least partially be explained by differences in the size of foreign and other firms. Foreign

10 For more detailed information on sectoral patterns see Annex Table A1.

firms are much larger than other firms in East Germany (Günther/Gebhardt 2005), and it is a typical empirical phenomenon that R&D intensity is higher in small and medium sized firms (SMEs) than in large firms (see e.g. Janz et al. 2003, Kleinknecht 1989).

As an additional indicator for the technological activity of foreign subsidiaries, our survey data provides information on different types of innovation activity (see Table 2). It shows that 69 per cent of the foreign subsidiaries in our sample reported a product or a process innovation activity during the respective time period (2002-2005). This is a high proportion if we compare to the East German manufacturing industry in total. According to the Mannheim Innovation Panel (MIP), the proportion of firms doing product (process) innovation in the whole East German manufacturing industry constitutes 47 per cent or 31 per cent respectively during the years 2003 to 2005.[11] It shows that not all the innovating firms are also R&D performing firms, which is a well known phenomenon in theoretical and empirical innovation research (Pavitt 2005, ZEW 2007). Looking at the output of product innovation activity, measured as the proportion of turnover with new products, the difference between foreign subsidiaries and the total of firms in East German industry is less pronounced. Foreign subsidiaries, according to our survey make 26 per cent of their turnover with new or considerably improved products compared to 22 per cent for the total manufacturing in East Germany (the latter figure: ZEW 2007).

Overall, the majority of foreign subsidiaries are actively involved in R&D and innovation; clearly above the average of East German manufacturing industry. This might at least partially be explained by the sectoral specialisation pattern of foreign subsidiaries, being more active in technologically advanced industries than the East German industry as a whole. What we can clearly conclude at this point is that the vast majority of international investors decide to place not only production but also technological activities in their East German subsidiaries.

For the empirical analysis in this paper we define “technological activity” of a foreign subsidiary in a very broad sense, namely the subsidiary is technological active when it had any R&D expenditures (in 2005) or own product or own process innovation (between 2002 and 2005). According to this definition 82 per cent of the foreign subsidiaries in the sample are technological active (see Table 2). Yet, we assume in line with the theory outlined above that there is considerable heterogeneity among technological active subsidiaries with regard to the extent that they source technology from various actors in the regional innovation system of East Germany. The survey provides this key information for suppliers, customers, and scientific institutions[12]

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11 Our survey data and MIP data is not exactly comparable at this point. MIP data refers to 2003 – 2005 (three years period) while our survey refers to 2002-2005 (four years period). This might be one reason for the comparatively high share of innovating subsidiaries. However, no other comparative figures are available (IAB establishment panel does only survey product innovation, not process innovation).

12 Science organisations are defined as universities, universities of applied sciences, and research institutes outside university.

based in East Germany. Technologically active foreign subsidiaries have been asked to "assess the importance of each of the above actors for their own R&D or innovation activity today". Subsidiaries provided the corresponding answers on a scale from 1 (not important) to 5 (extremely important).[13] Indeed, the frequency distribution of the answers provided by technological active subsidiaries confirms that the technological sourcing seems to be heterogeneous (see Table 3).

In our sample 68 technological active foreign subsidiaries ascribe importance (answers range between 'important' and 'extremely important') to East German science organisations as a source of technological knowledge whereas 101 firms indicate that they are of 'little importance' or 'not important'. This implies a ratio of 'importance' to 'non-importance' of 0.67. This ratio is 0.58 and 0.47 for East German customers and suppliers respectively. This simple descriptive statistic indicates that the majority of technological active foreign subsidiaries do not intensively source from the East German innovation system. However, the share of technological active subsidiaries that do so is still considerable: 40 per cent for scientific institutions, and 37 per cent and 32 per cent for customers and suppliers respectively. Thus, East German scientific institutions are most frequently indicated as source of importance for technological knowledge followed by customers, and suppliers. In order to explain this heterogeneity of foreign subsidiaries‘ technological sourcing behaviour we need to turn to regression analysis in the following section.

Table 3:
Frequency of Answers Provided: Importance of East German Suppliers, Customers, and Scientific Institutions as Foreign Subsidiaries' Source for Technological Knowledge Today

	Suppliers	Customers	Scientific Organisations
Not important	82	71	65
Little important	29	34	36
Important	31	30	43
Very important	18	25	20
Extremely important	3	6	5
No answer	19	16	13
Total	182	182	182

Source: FDI micro database of the IWH, own calculations.

3.3 Estimation Approach

As already described above we measure the importance of each of the actors (suppliers, customers, scientific institutions) as a source of technological knowledge with a five-

13 The database also provides information on the technological importance of suppliers, customers, scientific organisations based in West Germany and abroad (inside/outside the international company group).

point rating scale (ranging from not important, little important, important, very important, to extremely important). Following Wooldridge (2002) and Greene (2003), ordered probit models should be applied if the dependent variable is categorically scaled. The variable gives information about a ranking of different outcomes, where distances between outcomes are not necessarily identical or known. Therefore, we build the model as follows:

$$y^* = x'\beta + \varepsilon \tag{1}$$

Where y* is the unobserved endogenous variable, β is the parameter vector and ε is the error term. The real y is unobserved because the answers are given only in some discrete value that best fits the real y of the person interviewed. Therefore, we only observe whether an answer falls into a particular category or not in the following way:

$$\begin{aligned} &y = 0 \text{ if } y^* \leq 0, \\ &y = 1 \text{ if } 0 < y^* \leq \mu_1, \\ &\vdots \\ &y = J \text{ if } \mu_{J-1} \leq y^* \end{aligned} \tag{2}$$

Where μ_j are the unknown parameter to be estimated with β. These are also termed as J^{-1} cut off points. Greene (2003) argues that it is a sufficient assumption that the distribution is known and continuous as for all maximum likelihood estimations. However, in probit models we also assume that ε is normally distributed with mean equal to zero and variance equal to unity. Thus, we get a likelihood function of the following form:

$$\begin{aligned} &\Pr(y = 0 \mid x) = \Phi(-x'\beta), \\ &\Pr(y = 1 \mid x) = \Phi(\mu_1 - x'\beta) - \Phi(-x'\beta), \\ &\vdots \\ &\Pr(y = J \mid x) = 1 - \Phi(\mu_{J-1} - x'\beta) \end{aligned} \tag{3}$$

The above outlined relies on the assumption that the residuals are homoscedastic and normally distributed. Therefore, we estimate with heteroscedasticity robust standard errors. Equations (4.1) shows the specification with the importance of East German suppliers as source for technological knowledge for the foreign subsidiary:

$$\begin{aligned} P(y = J \mid x) = 1 - \varphi(\mu_{J-1} - (&\beta_1 AU_i + \beta_2 EX_i + \beta_3 SUP_i + \beta_4 AUT_i + \\ &\beta_5 AGE_i + \beta_6 SIZE_i + \beta_7 HC_{jri} + \beta_8 HE_{ri} + \beta_9 KS_{jri} + \beta_{10} AGL_{jri} + \beta_{11} IND_{ji} + \varepsilon)) \end{aligned} \tag{4.1}$$

where the parameter β_1 to β_6 measure subsidiary specific effects. Parameter β_1 indicates to which extent the subsidiary follows a competence or home base augmenting strategy. This variable is approximated by the number of *other* actors (other suppliers, customers, scientific institutions) based in West Germany or abroad, which the subsidiary considers to have at least some importance as source for technological knowledge (0 is the minimum, 6 the maximum). The parameter β_2 captures the extent to which the subsidiary follows a competence or home base exploiting strategy. This is approximated by the extent to which the foreign parent is a source of technological knowledge for the foreign subsidiary in East Germany (scale: 1 - "not important" to 5 - "extremely important")[14]. The effect of local supplies (in per cent of total supplies) is accounted for by parameter β_3. The parameter β_4 accounts for the effect of subsidiaries' autonomy, which is approximated by the average of subsidiaries' autonomy exercised across seven different business functions: operative management, market research/marketing, research, product development, process development, strategic management, and finance (scale: 1 only investor to 4 only subsidiary). The parameter β_5 captures for any firm specific effects related to age of the subsidiary measured by the years since the entry of the foreign investor.

The parameter β_6 controls for any effects to the size of the subsidiary measures in the number of employees in the year 2005. The parameter β_7 to β_{10} deal with regional level variables. The parameter β_7 estimates the effect of the human capital stocks in the sector and region[15] the respective subsidiary is located in. It is approximated by the sectoral share of employees working in science and technology occupations in 2005 (share of HRSTO employment at NACE 2-digit level to total employment at NACE 2-digit level within the region[16]). The parameter β_8 estimates the effect of the intensity of R&D expenditures by higher education institutions within the region in 2005 (total R&D expenditures by HE institutions per employee within the region[17]). The parameter β_9 estimates the effect of the regional knowledge stock, which is approximated by the intensity of sectoral patent application within the region (number of patent applications between 2002 and 2004[18] within the respective sector - at NACE 2-digit level - and region divided by the number of total employees in the respective sector and region 2004). The last regional variable β_{10} estimates agglomeration effects, measured by the sectoral employment density (number of employees – at NACE 2-digit level – per square km in the respective region and industry). Finally parameter β_{11} is introduced into the specification and controls for any effects of the industry (NACE 2- digit) to

14 Distances between these answers cannot necesarily be interpreted to be same. Therefore, we alterntaivly use a binary code. Results, however, do not change.

15 As a regional unit we use for all relevant variables '*Raumordnungsregionen*' which are 23 administrative-functional units within East Germany taking into account commuter movements between peoples' residence and work places. Each ROR consist of two to six countries (Kreise). For more details see Bundesforschungsanstalt für Landeskunde und Raumordnung (1996).

16 Source: BA-Statistik (2007), and calculations IWH.

17 Source: Statistisches Bundesamt (2005), Bildung und Kultur, Monetäre Hochschulstatistische Kennzahlen, Fachserie 11, Reihe 4.3.2 (includes R&D expenditures and R&D personell), and calculations IWH.

18 Source: Deutscher Patentatlas (2007), and calculations IWH

which the subsidiary belongs to by using 11 dummies for different manufacturing industries[19].

The equation (4.2) shows the specification with the importance of East German customers as source for technological knowledge for the foreign subsidiary:

$$P(y = J \mid x) = 1 - \varphi(\mu_{J-1} - (\beta_1 AU_i + \beta_2 EX_i + \beta_3 SAL_i + \beta_4 AUT_i + \beta_5 AGE_i + \beta_6 SIZE_i + \beta_7 HC_{jri} + \beta_8 HE_{ri} + \beta_9 KS_{jri} + \beta_{10} AGL_{jri} + \beta_{11} IND_{ji} + \varepsilon)) \quad (4.2)$$

The only difference to equation (4.1) above is that the parameter β_3 captures the effect of local sales (in per cent of total sales). This is in line with our hypotheses development. The equation (4.3) shows the specification with the importance of East German scientific institutions as source for technological knowledge for the foreign subsidiary:

$$P(y = J \mid x) = 1 - \varphi(\mu_{J-1} - (\beta_1 AU_i + \beta_2 EX_i + \beta_4 AUT_i + \beta_5 AGE_i + \beta_6 SIZE_i + \beta_7 HC_{jri} + \beta_8 HE_{ri} + \beta_9 KS_{jri} + \beta_{10} AGL_{jri} + \beta_{11} IND_{ji} + \varepsilon)) \quad (4.3)$$

The only difference to specification (4.1) and (4.2) is that we exclude β_3 *as estimation* parameter, where we do not expect any effects according to our hypotheses.

To evaluate whether the models as such are significant, we perform a Wald-test under the assumptions of consistency and asymptotic normality (White 1982). We also present the McFadden-R², but as we are dealing with a non-linear model it is not bounded by zero and unity, therefore, the value of the Pseudo-R² can be interpreted as an absolute value only, where the introduction of the covariance matrix in the model increases the probability of the event occurring.

4 Estimation Results and Discussion

According to the estimation results (see Table 4), we find that the more external technological sources exist to be of importance to the foreign subsidiary (apart from the East German ones), the higher the propensity to source intensively from East German suppliers, customers, as well as scientific institutions. This implies that foreign subsidiaries actively search for new knowledge beyond the established knowledge base of the foreign investor (Frost 2001). Thus, the foreign parent mandated the subsidiary with a home base augmenting approach to innovation and technology development in order to enhance the firm specific advantages of the whole corporation (Cantwell and Mudambi 2005). Therefore, we cannot reject hypothesis (1), that subsidiaries following

19 A correlation analysis shows that we should be safe from multicolinearity between exogenous variables. All correlations coefficients are below 0.5. However, regional patent intensity is considerably correlated with the R&D expenditure of higher education institutions (0.496) (see Annex Table A2).

a competence augmenting strategy are more likely to source technological knowledge from the East German innovation system.

Table 4:
Ordered Probit Estimation Results: Determinants of Local Technology Sourcing of the Technologically Active Foreign Subsidiaries in East Germany

	Suppliers			Customers			Scientific Institutions		
	Coeff.	St. Err.	P>|z|	Coeff.	St. Err.	P>|z|	Coeff.	St. Err.	P>|z|
Firm specific variables									
Augmenting Strategy	**0.437**	0.067	0.000	**0.323**	0.074	0.000	**0.368**	0.064	0.000
Exploitive Strategy	0.007	0.074	0.928	**0.134**	0.055	0.014	0.039	0.053	0.461
Local sales				**0.033**	0.005	0.000			
Local supplies	**0.025**	0.005	0.000						
Autonomy	**-0.528**	0.232	0.023	**0.647**	0.195	0.001	0.294	0.213	0.167
Age	0.021	0.018	0.250	-0.012	0.019	0.532	0.001	0.020	0.975
Size	-0.000	0.000	0.331	0.000	0.000	0.336	0.000	0.000	0.481
Regional variables									
Human capital	0.016	0.015	0.293	**0.044**	0.025	0.086	0.010	0.018	0.558
HEI R&D expenditure	**0.001**	0.001	0.049	0.000	0.001	0.585	**0.001**	0.001	0.019
Patent intensity	**-7.674**	4.549	0.092	**30.31**	7.774	0.000	**-628.8**	229.3	0.006
Agglomeration	-0.041	0.026	0.122	**-0.075**	0.027	0.006	**-0.080**	0.026	0.002
Industry specific effects									
Dummies	yes			yes			yes		
No. of observations	140			143			144		
Waldchi^2	161.08			122.70			79.22		
Prob > chi^2	0.000			0.000			0.000		
Pseudo R^2	0.213			0.247			0.142		

According to Crisculo et al (2002) a foreign subsidiary is in most cases multi-technology based and, therefore, might be home-base augmenting in one technological field and home-base exploiting in another. Following Frost (2001), we expected in our second hypothesis that the intensity of technological knowledge sourced from the existing knowledge base (adaptive innovation strategy) of the foreign parent has a negative effect on the extent of subsidiaries' local technological sourcing. However, we find no statistical effect on technological sourcing from East German suppliers or scientific institutions. In contrast, we find a positive effect on the propensity to source technological knowledge from East German customers. This evidence might have two implications: First, the effect of an exploiting strategy could be different according to the technological source in question, in particular, for customers in a market seeking context. Second, the argument of Criscuelo et al. (2002), that foreign subsidiaries can follow both, competence augmenting and exploiting strategies for different technologies at the same time, seems to be reinforced. In other words, sourcing knowledge from the parent in one technological field, does not exclude external technological sourcing in another.

Furthermore, we tested whether a higher level of local trade leads to more technology sourcing from the regional innovation system. Indeed, the estimation results show that a higher level of sales to East German customers does have a positive effect on technology sourcing from East German customers. Thus, we cannot reject hypotheses (3), which is in line with Cantwell and Mudambi (2005) who point at the relevance of product and process customisation by subsidiaries in a competence-exploiting context. It also underlines the importance of user, and probably lead user in particular, for the innovation process of the firms (von Hippel 1976, 2005). Similarly, we find a positive effect of the intensity of suppliers from East Germany on the likelihood of technology sourcing from East German suppliers. This is in line with our fourth hypothesis and the literature on mutual benefits from backward linkages of foreign subsidiaries (Hoekman and Javorcik Smarzinska 2006, Giroud 2007).

We assumed that according to the literature (Birkinshaw et al. 1998, Andersson and Forsgren 2000, Andersson et al. 2002) on subsidiary roles and embeddedness that higher subsidiary autonomy results in an increased ability to form external technology linkages. However, our estimation results seem to support this hypothesis only for technology sourcing from East German customers. We find no statistical effect for scientific organisations, and even a negative effect of autonomy on the intensity of technology sourcing from East German suppliers. This would imply if the foreign parent controls by large or fully the subsidiary across all business function, technology sourcing from suppliers becomes more likely.

Frost (2001) argued that older subsidiaries would be more likely to source technology from the host country. He actually found a negative effect at the level of the host country and no statistical effects at the regional level. The latter applies also to our findings for East Germany. Similarly, we did not find any statistical effect of the subsidiary size on local technology sourcing. It could be possible that the effects for both variables are non-linear.

Now we turn to the set of exogenous regional variables. We expected according to our hypothesis (7.1) that human capital endowment within a region is positively related with external technology sourcing of foreign subsidiaries. More specifically, we tested for the effect of the share of highly qualified jobs within the sector and region of the subsidiary. We find no statistically significant effect for the likelihood to source technological knowledge from scientific organisations or East German suppliers. However, the effect is statistically significant and positive for East German customers. Maybe one deficiency of our proxy is that we focus on the same sector the subsidiary operates in and not vertically related sectors. However, the sector category – NACE 2-digit – is fairly broad and should capture some potential linkages.

Testing hypothesis (7.2) we find a positive effect of the intensity of R&D expenditure in higher education institutions, on the propensity to source technological knowledge from scientific organisations as well as suppliers. This evidence could indicate that in East German regions, that are more intensive in terms of expenditures (including personnel) for R&D at higher education institutions, we see direct positive economic effects through the commercialisation of public research outcomes by foreign subsidiaries, as well as indirect positive effects by capability building of East German suppliers that operate as technological source for foreign subsidiaries.

Hypothesis (7.3) argues that the higher the regional knowledge stock, the more inclined are foreign subsidiaries to source technology locally. We approximated the knowledge stock by the patent intensity of the sector in which the subsidiary operates within the respective region. Surprisingly, we find a negative effect for technology sourcing from East German suppliers and scientific organisations. The effect is positive for East German customers. This could be related to the nature of our proxy. It signals that a sector is above patent intensive in comparison to the same sector in other region i.e. its knowledge production is above average. However, it also signals that the knowledge production is in need of particular protection by applying for patents. This could imply that foreign subsidiaries in such sectors are reluctant to share knowledge about technological development with local universities or suppliers, which might also have contact to competitors. This counter effect might not exist in the case of customers or users of products, where in contrast technological knowledge from East German customers feeds into knowledge production by foreign subsidiaries.

According to our final hypothesis (7.4), we expected positive effects of industrial agglomeration. However, the effect is statistically not significant for technology sourcing from suppliers, and must even be rejected in the case of East German customers and scientific institutions, where the effect is negative. Thus, within regions that show lower density in terms of employment within a particular sector compared to other regions, foreign subsidiaries are more likely to source technological knowledge from the customers and scientific institutions. We would be cautious with regard to strong conclusion about the relevance of agglomeration effect, because our proxy might compound intra- and inter-sectoral effects.

In sum, we would argue that our study makes an important contribution to the literature by analysing the determinants of local technological sourcing for different actors from a regional innovation system. Current empirical work in the field is to our knowledge restricted to patent citation analysis. Our estimation results based on survey evidence shows that subsidiary specifics as well as regional variables are able to explain some of the heterogeneity of technological sourcing behaviour. We find that foreign subsidiaries following a competence-augmenting strategy are more likely to source technology locally. However, this does not a priori imply that competence-exploiting subsidiaries fail to do so in general. Furthermore, we show the importance of regional human capital and a scientific infrastructure for the intensity of external technology linkages of foreign subsidiaries.

However, our analysis suffers from some caveats. The current estimation approach does not take account of the R&D or innovation intensity of foreign subsidiaries. We simply assume that all subsidiaries are homogeneously technologically active. This is certainly not true, however, as outlined above the theoretical literature is not clear whether the causality run from the extent of technological activity (R&D or innovation) to external technology sourcing or vice versa. If the direction is clarified, it would be possible to employ an estimation approach that accounts for the endogenous covariate. Our list of exogenous variables is certainly not yet fully specified[20]. For example, in line with the theoretical thinking of Cantwell (1992, 1993) we could imagine to include variables that approximate the regional technological advantage in comparison to the home country of the foreign investor. Furthermore, our results indicate that it might be insightful to differentiate the regional variables into intra- and inter-sectoral effects (human capital, knowledge stock, and agglomeration).

5 Summary and Policy Conclusions

With respect to foreign subsidiaries in East Germany, some authors have concluded that the East German innovation system does clearly not fulfill international investors' expectations (Koschatzky et al. 2006).

In contrast, our empirical study calls for a differentiated perspective. Against wide-spread believes, we observe a very high proportion of technologically active foreign subsidiaries (80 per cent) in the East German manufacturing industry. This is based on a broad definition of technological activity (R&D or product innovation or process innovation). But still, as many as 60 per cent of the foreign subsidiaries engage in own R&D activity – a proportion clearly above the average of the East German industry as a whole. Thus, the East German innovation system seems to be attractive for international investors' technological activities. Practical examples for this are foreign investments in the electronic industry (AMD), chemical industry (DOW), or investors in the quickly growing East German solar industry (Qcells, EverQ etc.).

20 For example, we also introduced a dummy for all FDI greenfield versus acquisition projects. The dummy is not significant in equation (5.2) and (5.3). However, greenfield projects have a negative significant effect on technological sourcing from East German suppliers. Due to multicolineraity of the Greenfield dumms with other exogenous variables in specification (5.1), we decided to exclude the dummy. Results are available upon request.

But how about the integration of foreign subsidiaries into the regional innovation system? Do foreign subsidiaries actually pay attention to local actors as a source for own technological activities? Here, the descriptive analysis of our survey data shows that the technology sourcing activities are still limited, but different with respect to different actors. Remarkably is the relatively high importance ascribed to East German scientific organisations. As many as 40 per cent of the foreign investors source technology from this type of actor (customers: 37 per cent, suppliers: 32 per cent).[21] The East German scientific infrastructure obviously provides a suitable platform for technological cooperation with foreign investors. Obviously this is a result of substantial public investment into the scientific infrastructure, which led to a rich endowment in particular with respect to outside university research institutes (Max Planck, Fraunhofer, and Leibniz Institutes) (Pasternak 2007, Roth 2006). Numerous cases can be pointed out here, such as the close cooperation between the emerging solar tech industry in East Germany and local universities as well as the newly founded Fraunhofer Center for Solar Technology. Nevertheless, there seems to be some weakness with respect to technological interaction of foreign investors with local customers and especially with suppliers – a finding that should call for policy makers attention.

What does finally determine the technology sourcing behaviour of foreign subsidiaries confronted with different actors in the East German innovation system? Here, we observed that the strategic orientation of international investors as well as regional framework conditions matter. A more competence-augmenting investment strategy increases the probability that a subsidiary interacts with all three types of partners in the East German innovation system; a stronger competence-exploiting strategy instead leads to technology sourcing only with local customers. Finally, both types of investors contribute to the consolidation of the local innovation system. A preference for one or another type should not be favoured, especially if one considers that investment strategies underlie dynamic developments, too.

As regards the regional framework conditions, it shows that human capital as well as R&D expenditure of higher education institutions have a positive impact on the foreign subsidiaries technology sourcing behaviour. This underlines the importance of investments in education and R&D. Here, the actual policy of the German government (high tech strategy) points to the right direction.

With respect to innovation policy, it seems advisable to continue with instruments that foster cooperation between different actors within the East German innovation system (*Verbundprojektförderung*). According to our findings, particularly vertical partnerships should be paid attention to. However, one should not expect too much from project financing alone. In addition, the introduction of a general tax allowance for R&D

21 An earlier empirical study (using MIP data) on innovation cooperation of all firms in the East German manufacturing industry revealed a similar tendency: scientific organisations turned out to be the most important cooperation partners (Günther 2004).

activities should be considered in German economic policy. The vast majority of OECD countries has already introduced tax allowances for R&D performing firms. This would provide an additional incentive to international investors to locate or to keep and upgrade technological activities in East Germany.

Overall, the East German innovation system should not be underestimated as a strategic locational factor to attract foreign investors. The rich scientific infrastructure should play an important role when marketing the East German business locations internationally. Here, East Germany has a clear advantage against competing locations in Central and Eastern Europe where the science and innovation system is still misaligned and still suffers from unsolved problems related to the socialist past (McGowan et al. 2004). However, several Asian locations seem to be quickly catching-up in terms of aligning their innovation systems to the needs of international cutting-edge technological investment projects (Legler et al. 2007).

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Annex:

Table A1
Sectoral Specialization of Foreign Subsidiaries in East German Manufacturing Industry versus East German Manufacturing Industry as a Whole - Number of Firms and Employment 2005 -

Industries (NACE 2-digit)	Foreign subsidiaries in East German manufacturing industry*				Total East German manufacturing industry **			
	No. of firms	in %	Employment	in %	No. of firms	in %	Employment	in %
Food and tobacco	75	6.9	21,091	10.9	6,132	17.7	121,078	15.0
Textile, leather and clothing	33	3.0	2,613	1.3	2,521	7.3	40,050	5.0
Wood and wood products	28	2.6	2,772	1.4	1,459	4.2	35,496	4.4
Paper, publishing, printing	83	7.6	7,192	3.7	1,087	3.1	22,542	2.8
Chemical industry	98	9.0	32,147	16.6	739	2.1	41,872	5.2
Rubber and plastic	61	5.6	5,804	3.0	1,480	4.3	43,991	5.4
Non-metallic mineral products	96	8.8	11,521	5.9	2,211	6.4	43,331	5.4
Basic metals and metal processing	38	3.5	11,857	6.1	541	1.6	36,214	4.5
Metal products	113	10.4	10,822	5.6	7,168	20.7	10,680	1.3
Machinery	110	10.1	10,501	5.4	3,294	9.5	125,834	15.6
Office and optical equipment	23	2.1	4,212	2.2	3,086	8.9	93,394	11.6
Electrical industry and telecommunication	195	17.9	39,132	20.2	1,750	5.1	41,454	5.1
Motor vehicles	52	4.8	14,064	7.3	479	1.4	20,862	2.6
Other vehicles	30	2.8	16,920	8.7	337	1.0	62,808	7.8
Furniture, and other manufacturing	37	3.4	20,85	1.1	2,266	6.6	43,717	5.4
Recycling	18	1.7	1,057	0.5	788	2.3	24,222	3.0
	1,090	100	193,790	100	34,550	100	807,545	100

Source: * FDI micro database of the IWH (total population); **IAB Establishment panel, own calculation.

Table A2:
Correlation Matrix of Dependent and Independent Variables

	Supplier	Customer	Scientific Inst.	Supplies	Sales	Age	Size	Auto-nomy	Augm. Strategy	Exploit. Strategy	Human Capital	Patent Intensity	Agglo-merat.	HEI-R&D exp.
Supplier	1.000													
Customer	0.173	1.000												
Scientific	0.175	0.134	1.000											
Local	0.487	0.075	-0.021	1.000										
Local sales	0.022	0.642	-0.088	0.145	1.000									
Age	0.019	0.021	-0.057	0.033	0.087	1.000								
Size	0.030	-0.029	0.056	0.038	0.024	0.123	1.000							
Autonomy	-0.101	0.136	0.138	0.016	0.099	-0.004	0.043	1.000						
Augm.	0.040	0.252	0.444	0.001	-0.021	-0.053	0.039	0.066	1.000					
Expl.	0.171	0.158	0.120	0.076	0.091	0.057	0.069	-0.039	0.124	1.000				
Human	0.124	-0.029	0.029	-0.067	-0.162	-0.094	-0.008	-0.019	0.205	-0.052	1.000			
Patent Int.	-0.051	-0.008	-0.062	-0.098	0.051	0.004	0.083	0.067	-0.136	-0.101	0.0151	1.000		
Agglomerati	0.103	0.008	0.103	-0.006	-0.141	-0.016	-0.124	0.008	0.144	-0.050	0.032	-0.287	1.000	
HE R&D	0.074	0.1095	0.012	-0.019	0.040	-0.033	-0.056	-0.043	-0.109	-0.053	0.335	0.496	0.366	1.000