Eastern European Economics, vol. 43, no. 3, May–June 2005, pp. 78–102.

ISSN 0012–8775/2005 $9.50 + 0.00.

JUTTA GÜNTHER AND OLIVER GEBHARDT

Eastern Germany in the Process of Catching Up

The Role of Foreign and West German Investors in Technological Renewal

ABSTRACT: *Foreign direct investment (FDI) as a means to support economic transformation and the ongoing process of catch-up development caught researchers' attention for a number of Central and East European countries. Little research, however, has been carried out for eastern Germany in this respect, although FDI plays an important role there too. Descriptive analysis via the use of unique survey data shows that foreign and west German affiliates perform much better with respect to technological capability and labor productivity than do east German firms. The results of the regression analysis, however, show that it is not the status of ownership as such that forms a significant determinant of innovativeness in eastern Germany but, rather, firm characteristics, such as firm size, export intensity, technical state of the equipment, and research and development (R&D) activities. Given that foreign and west German affiliates perform better with respect to all of these characteristics, they can be considered as a means to support the process of technological renewal and economic development.*

With the abrupt political changes of 1989–90, the former socialist countries of Europe suddenly faced the challenging task of rebuilding their societies and economies. In the economic research, much attention has been devoted to the economic restructuring process of such Central and Eastern European countries (CEECs) in particular, of which eight became members of the European Union (EU) in 2004. Although characterized by a special status due to German reunification, eastern Germany also faced and faces transition-related problems similar to those of the CEECs. Such challenges, inter alia, consist of the urgent need to restructure and modernize the entire industrial sector, to build up modern service branches, and to

Dr. Jutta Günther is affiliated with the Halle Institute for Economic Research, Halle, Germany; Oliver Gebhardt is affiliated with the University of Leipzig, Germany.

catch up economically with the West. For the CEECs, the benchmark has usually been the EU, while eastern Germany has usually been compared to western Germany. Since the beginning of transition, both the CEECs and eastern Germany have faced considerable progress, although the process of catching up has yet to be completed. Among the major tasks still ahead are the further adjustment of the standard of living and productivity catch-up.[1]

In the process of economic transformation and catching up, CEECs and eastern Germany alike have relied heavily on foreign direct investment (FDI) as a major source of investment, because private capital accumulation had until recently been nonexistent. West German investors have also played an important role in postreunification eastern Germany and, in that regard, they can be considered as "external" investors as well. Today, like in most CEECs, almost all big industrial plants in eastern Germany represent external, that is, west German or foreign, investment. Well-known examples of major foreign investments in eastern Germany are Dow Chemical in Schkopau, Elf Aquitaine in Leuna, and AMD in Dresden. Major west German investments are, for instance, BMW and Porsche in Leipzig, Bayer in Bitterfeld, or Volkswagen in Dresden.

However, foreign and west German firms have been considered not only an essential source of investments in eastern Germany, but also a transmitter of modern technology and management know-how. Policy makers expected a transfer of technology from the parent company to the foreign (western German) affiliate and, as a consequence thereof, that these affiliates would constitute a source of technology spillover to the benefit of local firms. In this context, the question regarding the technological capability of external investors arises. Are external investors in eastern Germany really characterized by technological superiority compared to pure east German firms? Are they more innovative? Are they strongly involved in R&D (if at all)? Do they perform better in terms of productivity? And, last but not least, is external ownership really a significant determinant of innovativeness in eastern Germany? These questions will be dealt with in this paper.[2]

Technological Capability of Foreign Affiliates—Theoretical Considerations

A variety of theoretical approaches explaining the existence of multinational companies has developed since the 1960s, when FDI became increasingly important in practice. Major contributions have come from Hymer (1960), who stressed "monopolistic" advantages as a driving force behind foreign affiliates; Vernon (1966), who emphasized the product cycle as a significant reason for the relocation of production from industrialized to less developed economies; and exponents of the internalization theory, who stressed the imperfections of technology markets (e.g., Buckley and Casson 1976, 1985; Rugman 1980, 1985).[3] The different theoretical explanations developed over time have been integrated by Dunning (1993: 75)

into the so-called OLI paradigm, which has become the standard theoretical framework for studies on foreign affiliates.[4] The OLI paradigm depicts under which circumstances a parent company establishes a foreign affiliate instead of entering the foreign market via export or via licensing to a local producer. According to Dunning, three conditions (O—ownership, L—local, and I—internalization advantages) must be fulfilled for a foreign affiliate to be established. First, the potential foreign investor—compared to the firms in the local market—must have *ownership advantages* (e.g., firm-specific product or production technology, marketing strategies). In order to regard production within this market as more efficient than exports, a second condition must be given, that is, the aspired foreign country must offer *locational advantages* (e.g., lower taxes, lower wages, cheap access to raw material). However, as it could still be more efficient to have a local company producing for the local market via license agreements, a third condition must be fulfilled, that is, the potential foreign investor must face *internalization advantages,* which means that it must be more efficient for the foreign investor to make use of the firm-specific technology within the multinational enterprise through an affiliate because asymmetric information makes license agreements impossible (failure of technology markets).[5] Only if all three conditions—ownership, locational, and internalization advantages—are given can a firm be duly expected to establish a foreign affiliate instead of engaging in export or licensing agreements.

Dunning's theoretical framework has, of course, primarily been developed in order to explain the existence of multinational firms, but by doing so, it lays the foundation for the assumption that foreign affiliates are technologically superior compared to domestic firms. The firm-specific technology (ownership advantages) "packed" (internalized) in a foreign affiliate makes foreign investors a source of new technology and knowledge within the host economy. Generally speaking, foreign affiliates benefit from the competitive strength (ownership advantages) of their parent company worldwide.

After presenting an overview of the extent of external investment in eastern Germany, including a comparison with the CEECs, the empirical part of this paper will investigate whether external affiliates in eastern Germany are really characterized by the theoretically stated superior technological capability. Building on this, a regression analysis will analyze whether "external ownership" as such really determines innovativeness in the east German economy. The data sources used in this paper are briefly described below.

Data Sources

When investigating the extent of foreign investments in eastern Germany, the use of official statistics provided by the Federal Bank of Germany (Deutsche Bundesbank) is an obvious possibility. This would bear, however, some limitations, especially with respect to the fact that west German investments do not count

as external investments in their statistics. Therefore, the paper predominantly relies on the German Institute for Employment Research of the Federal Employment Services (IAB) establishment panel as an alternative data source for both the general overview and the analysis of the technological potential. The latter can only be done through the IAB data in any event.

Official Statistics on FDI in Eastern Germany

In Germany, the Federal Bank is responsible for the collection of official FDI data. There are two methods of FDI data collection in Germany, for flow and stock data, respectively. Flow data are collected by the Federal Bank for the purpose of national accounts (balance of payments). These figures do not allow for any breakdown between eastern and western Germany. Therefore, they are not appropriate for the type of analysis carried out in this paper. The collection of stock data, on the other hand, is based on foreign affiliates' balance sheets, and therefore allows for a regional breakdown between eastern and western Germany. The legal basis for stock data collection is the German Foreign Trade Regulation (AVW). Since the beginning of 1999, companies with foreign ownership stakes exceeding 10 percent are subject to registration (Deutsche Bundesbank 2003: 71).[6] By implementing the 10 percent rule, German FDI statistics finally meet the international recommendations for FDI data collection given by the International Monetary Fund (IMF 1993). The compulsory registration of FDI, according to the AVW, applies to enterprises with a balance-sheet total of at least 500,000 euro. Because balance sheets are used for stock data collection, it is possible to determine where the FDI companies are located. However, the Federal Bank records FDI only at the principal German office of the foreign investor. It is not possible to separately account for establishments (local business units) that are founded from a foreign investor with a principal office in Germany. This may cause distortions when looking at regional FDI data. For example, an establishment in eastern Germany deriving investment from a foreign investor's principal office in western Germany is not identified as a case of FDI. Because it is probable that a number of foreign investments in eastern Germany have been carried out by foreign firms located in western Germany, the method of data collection causes an underestimation of FDI in eastern Germany.[7]

Survey Data on FDI in Eastern Germany: The IAB Establishment Panel

Different from official statistics, the survey data provided through the IAB establishment panel allows us to distinguish between majority foreign-, west German, and east German–owned establishments, and includes a number of indicators on technological capability (e.g., innovations, R&D) as well as general business indicators (e.g., sales, employment, investments).[8] Furthermore, it is possible to include the eastern part of Berlin, which contributes to data accuracy.

The IAB establishment panel is carried out annually. The panel is representative for the east German economy. All descriptive IAB data presented in this paper are projected figures using a weighting factor provided by the IAB. The basic population from which the sample is drawn is the employment statistics register of the Federal Employment Services. The register includes all establishments in Germany with at least one employee who is obliged to make social insurance contribution. That means that the survey unit is an establishment (i.e., a local business unit) and not the enterprise as a whole. This is a particular strength of the survey, especially when making investigations in the east German economy, because a number of west German–based enterprises have established affiliates in eastern Germany. The survey response rate usually reaches as high as 70 percent, because field interviewers are send out. In 2001, the number of properly filled-in questionnaires for the manufacturing industry amounted to 1,800 establishments for eastern Germany. Out of these, 628 companies are identified as external, that is, they represent foreign or west German investments, and 1,080 as east German establishments, as indicated by majority ownership. Seventy-two companies are classified as "others," that is, public enterprises and companies for which either there is no majority shareholder or it is unknown. Twenty respondents did not indicate any of the options provided. All figures calculated from the IAB establishment panel and presented below apply to the manufacturing industry in eastern Germany.[9]

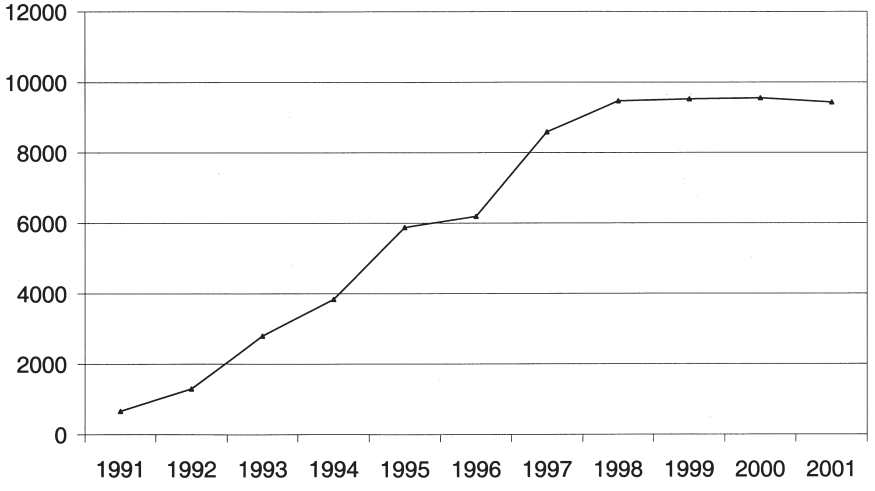
External Investors in Eastern Germany: An Overview and Comparison with the CEECs

According to official statistics, and corresponding to what one might expect, FDI in eastern Germany started from a very low level in 1991 (see Figure 1). FDI increased substantially in the following years, from 665 million euro in 1991 to 9,429 million euro in 2001. Since 1998, FDI more or less stagnates. FDI even declined slightly in 2001.

By the end of 2001, 78 percent of the FDI in eastern Germany had been invested in the manufacturing sector. Unfortunately, a further breakdown by branches of manufacturing industry is rather incomplete for reasons of data protection.[10] What is known, at least, is that the chemical industry plays an important role (accounting for 35 percent of all FDI into manufacturing). The high amounts of FDI in the chemical industry represent a number of big investments in the region of Halle, Wolfen/Bitterfeld, and Leuna/Schkopau.

In order to get an idea of the dimension of FDI in eastern Germany, it is reasonable to compare eastern Germany's FDI stock with other regions or countries. Thereby, a comparison to Central and Eastern Europe makes sense because the CEECs have also been attracting foreign investors since only the beginning of economic transition. Like every international comparison of FDI data, it is not free of problems related to data collection procedures. First, there are the generally known

Figure 1. **FDI Stock in Eastern Germany, 1991–2001** (million euro)



Source: Data obtained from Deutsche Bundesbank.
Note: Excluding Berlin.

difficulties with respect to the international comparability of FDI statistics (see, e.g., Döhrn 1996; Sachverständigenrat 1997: 64). Nevertheless, the harmonization of FDI data collection has improved substantially in recent years, especially in the CEECs (Borrmann 2003). Most important, all CEECs listed in Table 1, as well as Germany, apply the 10 percent threshold for the definition of FDI as recommended by the International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development (OECD) (IMF 1993; OECD 1996).[11] However, east German FDI statistics do not include investments from western Germany, as mentioned above. In order to gain better data comparability, German FDI has therefore also been excluded from the FDI figures for the CEECs (see Table 1).

Looking at the FDI stock in absolute figures, the Czech Republic, Hungary, and Poland far exceed eastern Germany. When taking into account the size of the country (region) by looking at FDI stock per head, it shows that all CEECs exceed eastern Germany. One has to take into account that this has partly to do with the underestimation problem, as explained above.[12]

Due to the deficiencies of measuring FDI via official statistics, the survey figures of the IAB establishment panel will be taken into account at this point as well. With the IAB establishment panel it is possible to discriminate between east and west German investors and thereby specify the proportion of external investments in relation to overall employment, investments, and sales—the more meaningful terms when looking at foreign affiliates' weight in an economy.[13] In eastern Germany, external investors account for 16.6 percent of all establishments but repre-

Table 1

FDI in Eastern Germany and in the CEECs in 2001

	FDI (million US$)	FDI per head US$
Eastern Germany (excluding Berlin)	8,414	690
Czech Republic*	26,764	2,012
Estonia*	3,160	2,263
Hungary*	23,562	1,517
Slovenia*	3,209	1,432
Poland*	41,031	862
Slovakia	5,582	803
Latvia*	2,332	880
Lithuania*	2,666	696

Source: Data obtained from Deutsche Bundesbank; Hunya and Stankovsky (2003).
*Excluding German FDI.

sent nearly 50 percent of the total employment, 65 percent of sales, and 63 percent of investments (see Table 2).

The figures already indicate that external investors, especially foreign establishments, are much bigger in terms of number of employees than east German establishments. And indeed, the average size of foreign establishments is about ten times higher than the size of east German firms. While the size of foreign and west German establishments increased over time (since 1998), the size of east German establishments remained almost unchanged (see Table 3).

Comparing the weight of external investors in eastern Germany with the CEECs, it can be shown that, differently from what official statistics suggest, external investors play a crucial role in east German manufacturing industry, too (see Figure 2). When looking at affiliates' proportion in overall employment, investments, exports, and sales, eastern Germany does not lag behind the CEECs. Furthermore, eastern Germany exhibits the highest share of external investors in employment (47.5 percent) and a comparatively high proportion with respect to sales, investments, and exports.

Are Foreign and West German Investors Characterized by Technological Superiority in Eastern Germany?

According to the theoretical considerations expressed above, it is assumed that foreign investors exhibit a higher technological capability and thus a better eco-

Table 2

Proportion of Foreign, West German, and East German Establishments According to Number of Firms, Employment, Sales, and Investments in Eastern Germany, 2001 (in percent)

	Number of firms	Employment	Sales	Investments
Foreign establishments	1.6	9.7	14.7	10.0
West German establishments	15.0	37.8	50.2	54.5
East German establishments	80.4	47.5	30.2	31.9
Other establishments*	3.0	5.0	5.0	3.6

Source: IAB establishment panel, calculation of the Halle Institute for Economic Research (IWH).

*Other establishments are majority public-owned establishments, establishments without a majority owner, or establishments where the majority owner is unknown.

Table 3

Average Size of Foreign, West German, and East German Establishments (number of employees)

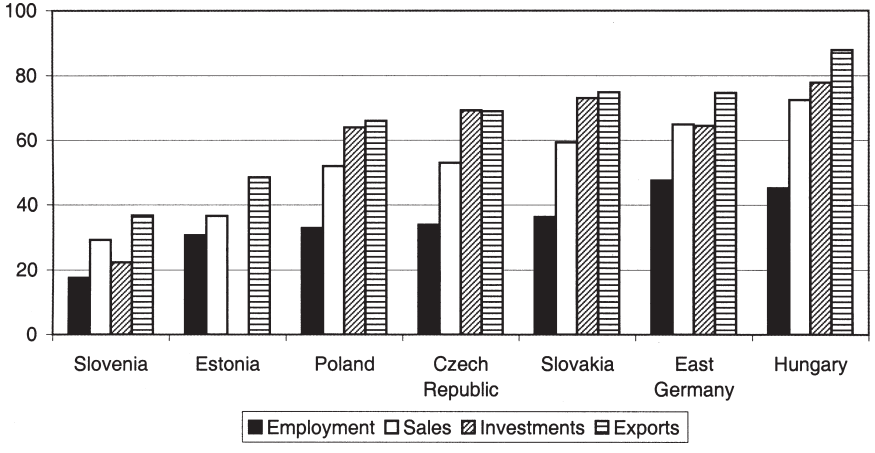
	1998	2001	2003
Foreign establishments	115	123	137
West German establishments	47	52	57
East German establishments	11	12	12

nomic performance than east German establishments. The same is basically expected with respect to west German establishments. In the following, an investigation of the technological capability of external and east German establishments is carried out based on the IAB establishment panel.

Low-, Medium-, and High-Tech Branches

As a first approach, the proportion of foreign, west German, and east German establishments in low-, medium-, and high-tech branches will be looked at. The classification used is based on an OECD concept that discerns four categories: "high-tech," "medium-high-tech," "medium-low-tech," and "low-tech" (Hatzich-

Figure 2. **Share of External Affiliates in Overall Employment, Sales, Investments, and Exports, 2001** (in percent)



Source: IAB establishment panel (eastern Germany); Hunya and Stankovsky (2003).
Note: For eastern Germany, the term "external affiliates" means foreign and west German investors (majority foreign- and west German–owned firms), for the CEECs, it means foreign affiliates.

ronoglou 1997).[14] Since the original OECD approach requires data with a breakdown up to four-digit NACE (*Nomenclature statistique des Activités économiques dans la Communauté Européenne* [Statistical classification of economic activities in the European Community]) branches, a modified classification has to be used because four-digit level data are not available. As suggested by Foyn (2001), and frequently applied in Eurostat publications, high-tech and medium-high-tech are collectively referred to simply as high-tech, and medium-low-tech is referred to as "medium-tech." Low-tech remains unchanged.

As presented in Table 4, the majority of external investors fall into the high-tech category (40.4 percent), while among the east German establishments, only 21.0 percent belong to high-tech branches. East German establishments are mainly present in low-tech branches, with 43.3 percent. This corresponds with the assumption that external investors are technologically more advanced. Yet, one has to keep in mind that multinational enterprises often outsource the labor-intensive aspects of their production, which do not necessarily represent the technology intensity of a respective branch. However, there is no other way to classify the given data. Finally, the results point to the expected direction.[15]

Product Innovations and R&D

Innovations and R&D activities are frequently used indicators for describing technological capability. Questions on R&D and innovation are included in the survey

Table 4

Foreign, West German, and East German Establishments According to Low-, Medium-, and High-Tech, 2001 (in percent)

	Low-tech[a]	Medium-tech[b]	High-tech[c]
External investors	34.6	25.0	40.4
East German establishments	43.3	35.7	21.0

Source: IAB establishment panel, calculation of the IWH.

[a] Low-tech: Food, beverages, tobacco; textiles, textile products, leather; paper, publishing, printing; wood, wood products; nonmetallic mineral products; recycling. [b] Medium-tech: Rubber, plastic products; basic metals; fabricated metal products; furniture, manufacturing n.e.c. (not elsewhere classified). [c] High-tech: Chemicals, chemical products (including petroleum processing, which actually belongs to medium-tech); machinery, equipment; motor vehicles; other vehicles (including shipbuilding, which actually belongs to medium-tech); electrical equipment; optical equipment.

(IAB establishment panel) every third year. So far, only two survey waves put questions on innovation. The establishment's statements on innovation refer to 1996–97 and 1999–2000, while the information on R&D alludes to the actual survey year. The IAB establishment panel distinguishes among three different types of product innovation:

1. substantial improvement or further development of an already existing product;
2. introduction of products which are new to the firm, but are already existent on the market (enhancement of the range of products); and
3. introduction of completely new products (market innovation).[16]

Process innovations are not a subject of the survey. The classification of product innovations largely corresponds to the international guideline for innovation surveys, the Oslo Manual (OECD/Eurostat 1997). The three types of innovation can be seen as a qualitative rank order of product innovations. The improvement and further development of already existing products is less challenging in terms of technological complexity than the introduction of completely new products. With respect to R&D, the IAB establishment panel refers to the existence of its own R&D activities in the relevant establishment. Further information (e.g., spending on R&D, R&D personnel) is not available.

No matter what type of product innovation one looks at, west German and especially foreign establishments perform better than east German establishments (Table 5). The differences are particularly striking when looking at market innovations, the most demanding form of product innovations. Looking at R&D, external

Table 5

Product Innovations and R&D of Foreign, West German, and East German Establishments (in percent)

	Product innovations (1999–2000)*					
	Product improved or further developed	Enhancement of the range of products	Market innovation	At least one type of product innovation (1999–2000)	All three types of product innovation (1999–2000)	R&D (2001)
Foreign establishments	66.4	39.8	30.2	79.2	9.6	46.7
West German establishments	47.8	29.1	12.3	54.4	4.5	22.9
East German establishments	38.8	25.1	10.8	44.7	5.6	10.7
All establishments	40.5	25.7	11.4	46.4	5.5	13.3

Source: IAB establishment panel, calculation of the IWH.

*Answers in response to questions on innovation in the 2001 survey refer to 1999 and 2000.

investors, especially foreign firms, show a much higher proportion of establishments that carried out their own R&D activities in 2001. Nearly half the foreign establishments were involved in R&D (46.7 percent), while only 22.9 percent of the west German and only 10.7 percent of the east German establishments engaged in R&D in 2001.

During the previous survey period (1996–97), foreign investors were already more strongly involved in innovation and R&D than German establishments. They even clearly increased their innovation activities from 1996–97 to 1999–2000, while German establishments' innovation and research activities slightly decreased or stagnated as found when comparing 1996–97 and 1999–2000.

Organizational Changes

Organizational changes constitute another form of innovation. Although they are not related to technological efforts in a narrow sense, they express a company's willingness to undertake internal changes. Generally speaking, organizational changes include "the introduction of significantly changed organizational structures, the implementation of advanced management techniques, and the implementation of new or substantially changed corporate strategic orientations" (OECD/Eurostat 1997: 54). The IAB establishment panel differentiates among nine types of organizational changes, as presented in Table 6.

Like in the case of product innovations, external investors are more active with respect to each of the organizational changes, except "more in-house production." It may be questionable whether the organizational changes listed in Table 6 necessarily contribute to the better performance of the firm. Apart from this, "more in-house production" and "more purchasing of products or services" are two sides of the same coin. But still, the introduction of new or the change of existing processes or techniques indicates flexibility and the willingness to engage in change. Finally, 61.2 percent of the external but only 46.7 percent of the east German establishments exhibit at least one organizational change in 1999–2000.[17] When looking at these figures, however, one should bear in mind that east German establishments are much smaller than foreign and west German firms. They employ twelve persons on average, as mentioned above. In such small establishments, it makes little sense to ask about certain organizational changes, such as "reorganization of departments or operational units" or "introduction of units with own cost-benefit calculation."

Market Orientation

Market orientation is not an immediate indicator of technological capability, but it can be assumed that firms with an international trade structure face higher competition and are thus forced to be more active with respect to technological advancement. In Germany, as shown in Table 7, foreign establishments show the highest

Table 6

Organizational Changes of External and East German Establishments, 1999–2000 (in percent)

	External investors	East German establishments	All establishments
More in-house production	15.2	19.6	18.8
More purchasing of products or services	11.5	10.9	10.8
Reorganization of purchasing or distribution channels	24.0	14.5	16.0
Reorganization of departments or operational functions	20.9	7.3	9.8
Relocation of responsibility	14.2	8.7	9.5
Introduction of teamwork	9.1	7.5	7.6
Introduction of units with own cost-benefit calculation	8.2	3.8	4.5
Environment-related organizational changes	13.9	5.5	7.1
Improvement of quality control	47.7	30.8	33.6
At least one organizational change	61.2	46.7	48.6

Source: IAB establishment panel, calculation of the IWH.
Note: Multiple answers were possible.

sales in foreign markets (29.5 percent). West German firms make 20.4 percent of their sales abroad, while east German establishments make only 9.3 percent of their sales in foreign markets. East German establishments have a clear preference for the east German market, where they make as much as 61.3 percent of their sales.

When looking at procurement markets, a similar pattern arises: east German establishments again have a priority for local (east German) markets, while foreign procurement markets are much more important for west German and foreign firms (Guenther 2004: 26).

Productivity

Not surprisingly, external investors, especially foreign firms, have higher productivity than east German establishments. This holds true for sales productivity (sales

Table 7

Market Orientation (Sales) of Foreign, West German, and East German Establishments, 2000 (in percent)

	East German market	West German market	Foreign markets
Foreign establishments	40.9	29.6	29.5
West German establishments	37.3	42.3	20.4
East German establishments	61.3	29.3	9.3
All establishments	45.5	36.2	18.3

Source: IAB establishment panel, calculation of the IWH.

per employee) as well as for value-added productivity (value added per employee). According to the IAB establishment panel, foreign establishments in 2001 exhibit a sales productivity that is 3.5 times that of east German establishments (and twice that of west German establishments). Value-added productivity of foreign and west German investors is about two times higher than that of east German establishments.

Thereby, one can assume that some of the higher productivity of foreign and west German establishments is due to the fact that they are dominantly present in high-productivity industries. Therefore, the "corrected" productivity of east German establishments has been calculated by supposing that east German establishments had a branch structure and establishment size structure as external investors, that is, productivity is corrected for branch structure and firm-size structure.

As shown in Table 8, east German establishments would indeed have higher sales productivity and higher value-added productivity if they had a branch structure and firm-size structure as external investors. But still, branch and firm differences do not fully explain the productivity gap, because the corrected figures do not reach the productivity of external investors. Looking at sales (value-added) productivity, differences in branch structure account for 15.4 percent (13.1 percent) of the productivity, while differences in firm-size structure explain 20.5 percent (16.6 percent) of the productivity gap between external investors and east German establishments.[18] The analysis shows that other factors not considered here may also be responsible for the lower productivity of east German establishments, such as differences in capital intensity, management, internal organizational structures, access to international distribution networks, and so forth.

Table 8

Sales Productivity and Value-Added Productivity of East German Establishments Corrected for Branch and Firm-Size Structure, 2000
(thousand euro)

	East German establishments		
	Actual value	Corrected for branches[b]	Corrected for firm size[c]
Sales productivity (sales per employee)	71.6	86.7	91.7
Value added productivity (GVA[a] per employee)	32.6	37.1	38.3

Source: IAB establishment panel, calculation of the IWH.

[a] GVA = gross value added. [b] Fourteen branches. [c] Five size classes (number of employees): 1–19, 20–49, 50–99, 100–499, >500.

What Determines Innovativeness in Eastern Germany?

Following the comparative analysis of external investors and east German establishments concerning different aspects of technological capability, below, a particular facet, that is, innovativeness, is scrutinized using an empirical model. Innovativeness is considered to be a decisive feature of a company's technological capability. And innovativeness is, in turn, the driving force behind the process of restructuring and catching up.

Descriptive analysis suggests a considerably higher innovative activity of external investors compared to their east German counterparts. Pursuant to the underlying theoretical considerations, it is analyzed to what extent external ownership, that is, parameters *exclusively* linked to ownership, accounts for this superiority, while controlling for other important determinants of innovativeness such as specific market and industry characteristics. From a rational point of view, status of ownership in a very narrow sense cannot be considered to have a self-contained influence on a firm's innovativeness. In fact, it is rather the features attached to this status that determine a company's propensity to innovate. Assuming that, for several reasons, some of these characteristics cannot be considered for analysis separately, but are somehow linked to the status of ownership, this variable has to be looked at in this context.

The data set used for applying the empirical model—the IAB establishment panel—was introduced above.[19] Therefore, in the following, we first concentrate on the introduction of the model formulated and the variables used for regression. Second, the regression results are presented and appraised.

The Empirical Model

Considering that most firm-level studies on innovation utilize input-oriented figures on R&D expenditure or patent data as proxies for innovativeness, the IAB establishment panel data set offers an opportunity to operationalize innovativeness in a rather direct and therefore more promising way. In this context, "direct" means focusing on the real effects of the innovation efforts conducted by a company. The dependent variable is a measure of innovation activity generated based on data on the three types of product innovation collected in the survey.[20] A firm is considered innovative if it carried out at least one type of product innovation within the period observed. Due to the yes/no character of the answers, the variable has a binary value, which provides the opportunity to formulate the following logistic regression model.[21]

$$\begin{aligned}\text{LOGIT(INN)} = {} & ß_0 + ß_1\text{SIZE} + ß_2\text{EXP} + ß_3\text{R\&D} + ß_4\text{TRAIN} \\ & + ß_5\text{SKILL} + ß_6\text{EQUIP} + ß_7\text{EXT} + ß_8\text{SUPDOM} + ß_9\text{SCALE} \\ & + ß_{10}\text{SPECSUP} + ß_{11}\text{SCIENCE}.\end{aligned}$$

The dependent variable (INN) discriminates between innovative and noninnovative establishments in eastern Germany in 1999–2000. The explanatory variables include firm size (SIZE), export intensity (EXP), state of the technical equipment (EQUIP), R&D activity (R&D), further education (TRAIN), human capital endowment (SKILL), external ownership (EXT), and different dummy variables for estimating the scope for innovation according to industry-specific characteristics (SUPDOM, SCALE, SPECSUP, SCIENCE). These variables are considered for the following reasons:

It is expected that the number of employees in 1999 taken as a logarithm and used as a proxy for firm size (SIZE) has a positive and significant impact on the firm's propensity to innovate. This assumption arises from the fact that larger firms tend to dispose of more funds in order to carry out R&D activities, which, in turn, tend to have a positive impact on the probability of generating innovations. Furthermore, innovation activities are characterized by economies of scale.[22]

Another important explanatory variable is a company's export intensity (EXP), measured as the share of exports in total sales in 2000. The underlying theoretical consideration claims that having to compete in international markets increases the necessity and, thus, the propensity to innovate. Hence, a positive and significant impact is expected.[23]

As already mentioned above, it is assumed that there is a strong relationship between R&D activity and the probability of generating innovations. Normally, it is taken for granted that innovations are the result of in-house R&D activities, though this is just one possibility to gain access to new marketable knowledge. Licensing, cooperation agreements, and the utilization of information characterized by a public-good nature constitute other ways to obtain such expertise. Nevertheless, in-house R&D can be considered to have a rather positive and significant

impact on innovativeness. Due to restrictions of the data set, expended R&D activity is also measured as a dichotomous variable, reflecting whether or not such activities have been carried out.

A firm's stock of human capital as well as its efforts to further develop it play a crucial role not just in enhancing its absorptive capacity to assimilate and commercially apply external knowledge, but also to generate innovations autonomously.[24] Therefore, the stock of human capital (SKILL) and the promotion of further education (TRAIN) are considered as explanatory variables within the model. Using the data available, human capital is measured as the share of qualified employees and skilled workers of the total workforce. In principle, a positive impact of human capital on the innovativeness of a company is expected. Due to the way human capital is operationalized, by looking at the *formal* level of qualification, it is questionable whether the coefficient to be obtained is significant. A company's willingness to increase the existing stock of knowledge is measured by its efforts to promote further education by means of special company leave or bearing the costs of such training. On the basis of the data at hand, the variable TRAIN gives evidence as to whether such promotion has taken place or not.

Another important determinant concerning a firm's ability to generate real innovation or product-enhancing innovations constitutes its endowment with state-of-the-art equipment. Hence, the individual firm's assessment in this respect (EQUIP) is used as an independent variable within this model, which is expected to have a positive and significant impact on a company's innovation propensity.

The dummy variables used for controlling for industry-specific characteristics follow the taxonomy introduced by Pavitt (1984). They relate these characteristics to the realization of innovations. Pavitt describes four types of sectors: (1) the supplier-dominated sector (SUPDOM), which is characterized by the fact that a major part of process and product innovations comes from suppliers of equipment and material; (2) the scale-intensive sector (SCALE), which is to be distinguished by a substantial contribution of the sector's firms to all innovations produced within the specific industry; (3) the specialized equipment supplier sector (SPECSUP), which primarily generates product innovations for use in other sectors; and (4) the science-based sector (SCIENCE), which produces a relatively high proportion of its own process technology as well as many product innovations that are used in other industries.[25] Positive and significant effects on the dependent variable are expected for all branches except the supplier-dominated sector. For this particular sector, a negative impact is predicted.[26]

Regarding the main purpose of this regression, the binary variable EXT represents the most interesting determinant to be analyzed concerning its impact on the probability of a company to innovate. The explanatory variable indicates whether a company's major shareholder is an external, that is, a foreign or west German, investor (EXT). According to the results of the descriptive analysis and the underlying theoretical considerations expressed above, a positive and significant impact on the dependent variable is expected.

The Estimation Results

As a result of missing data in some of the explanatory variables used for regression, 1,283 of the 1,800 cases of the sample were included in the analysis. The model specified is characterized by a high and significant chi-square value and Nagelkerke's R^2 value of 0.364.[27] These values indicate a reasonable explanatory power of the model considering the underlying limitations of the analysis. These limitations derive, inter alia, from the operationalization of the variables being restricted by the data at hand and by the capturing of some influential "soft" parameters—such as, for instance, expectations related to current business cycles—being impossible because they are hard, if not impractical, to measure. Thus, given the theoretical and practical accuracy of the analysis, and given that the data set used can be considered as very appropriate for such a type of regression, the results presented can be regarded as valid.

Table 9 summarizes the coefficients calculated that reflect the particular explanatory variable's impact on a firm's probability to innovate, holding the other independent variables constant. The coefficients of the dummy variables included in the analysis indicate their impact on the dependent variable in relation to the dummy left out of the regression. Almost all coefficients are as predicted.

The independent variables firm size (SIZE), export intensity (EXP), state of the technical equipment (EQUIP), R&D activity (R&D), and further education (TRAIN) seem to have a positive and significant impact on the probability of an establishment in eastern Germany to innovate. Surprisingly, no significant coefficients could be estimated for the parameters human capital endowment (SKILL), external ownership (EXT), and the other dummy variables controlling for industry-specific characteristics.

Confirming the apprehension expressed earlier, the human capital endowment variable (SKILL) did not perform according to the theoretical assumptions, as reflected in numerous studies published regarding this subject.[28] A comprehensible explanation for this observation already has been hinted at within the context of introducing the variable to the model. Given that (1) the variable used for regression solely reflects the formal level of qualification, and (2) presuming that there is a considerable gap between the formal and de facto level of qualification, and (3) hypothesizing that primarily the de facto qualification of the workforce determines, inter alia, the innovativeness of a company, and considering the results of the regression, it can merely be stated that there is no relation between the formal level of qualification of an establishment's workforce and its propensity to innovate. In respect to the interplay between de facto qualification and the probability of a company to innovate given the data at hand, no conclusion can be drawn.

Very surprisingly, the variable central to this analysis, namely, the status of the ownership of an establishment, turns out to have no statistically significant impact on a firm's propensity to innovate. The same holds true for the sector variables. As

Table 9

Logit Estimation Results on the Determinants of Innovativeness in Eastern Germany

Explanatory variables	Coefficients
Constant	–2.2289***
	(0.4250)
SIZE	0.2178***
	(0.0592)
EXP	0.0210***
	(0.0059)
EQUIP	0.3853***
	(0.0889)
R&D	2.5170***
	(0.2498)
TRAIN	0.3225**
	(0.1474)
SKILL	–0.0049
	(0.0030)
SPECSUP	0.0094
	(0.1946)
SCALE	0.0276
	(0.1612)
SCIENCE	0.0268
	(0.2647)
EXT	0.0209
	(0.1641)
Observations	1283
Chi-square	407.79***
Nagelkerkes R^2	0.364

** and *** denote significance at levels of 5 percent and 1 percent, respectively. Standard errors are in parenthesis.

regards the ownership variable, one has to keep in mind what the variable stands for. The status-of-ownership variable is used for controlling for status-specific parameters influencing a firm's innovation performance that cannot be specified otherwise. In other words, when already including "firm size," "R&D activity," "condition of equipment," "export intensity," and such as self-contained variables in the model, EXT only captures qualitative characteristics exclusively linked to

ownership status that could not be operationalized separately, such as, for instance, tacit knowledge. But despite the unexpected result with respect to "ownership," it remains remarkable that firms owned by external investors are (1) considerably bigger; (2) prone to be engaged in R&D activities; (3) more likely to be assigned to the rather innovation-prone high-tech sectors; (4) on average, technically better equipped; (5) more likely to promote the further education of their employees;[29] and (6) characterized by a substantially more intense outward orientation in terms of sales and procurement markets, and that these six categories are, in fact, crucially important regarding a company's propensity to innovate.[30]

Summary and Conclusions

Like in most transition countries, official statistics show that there has been a strong increase of FDI in eastern Germany since the beginning of transition. But different from CEECs, figures on FDI in eastern Germany do not capture the whole of external investment there. Naturally, west German investment plays an important role in eastern Germany, too, as was shown in this paper by the use of unique and representative survey data. In sum, the penetration of external—that is, foreign and west German—investments in eastern Germany is nearly as high as in Hungary, the country with the highest FDI penetration in the Central and Eastern European region.

Comparing the technological capability of external investors on the one hand, and east German establishments on the other, all indicators point in the same direction, namely, the technological superiority of external investors in eastern Germany. This is particularly striking when looking at the more direct measures of technological capability, that is, product innovations and R&D. Considering this, it is not surprising that external investors also perform better with respect to sales and value-added productivity. Even if one "corrects" the productivity of east German establishments for the branch and firm-size structure of external investors, a clear productivity gap between the two sides remains.

Descriptive analysis suggests the considerably higher technological capability of external investors compared with their east German counterparts. The results of the regression analysis undertaken in this regard indicate that it is not the status of ownership as such that forms a significant determinant of innovativeness, but rather general firm-specific characteristics, such as firm size, export intensity, state of the technical equipment, R&D activities, and further education. Given that external investors perform better with respect to all of these categories, and owing to their superiority in terms of sophistication of technology applied and productivity, they can be considered as a means to increase the overall technological capability and, thus, productivity in eastern Germany.

Apart from this, the technologically superior foreign and west German investors serve as potential sources of technology spillover in favor of east German firms. The latter aspect calls for further research, especially considering that

technology spillovers from FDI have yet to be investigated in the case of eastern Germany.

Notes

1. In eastern Germany, productivity still lags clearly behind the western part of the country. Since the mid-1990s, the process of productivity catch-up between east and west has nearly been completed. In 2002, eastern Germany reached 72 percent of west Germany's productivity in manufacturing (DIW Berlin/IAB/IfW/IWH/ZEW 2003: 15). For further information regarding the progress of closing the productivity gap between the EU-15 (i.e., the fifteen member states of the European Union prior to the 2004 enlargement) and the CEECs, see Stephan (2003).

2. Few empirical studies exist on the role of foreign (and west German) firms in eastern Germany. Basically, there are two current empirical studies that deal with the economic performance of external investors in eastern Germany (Belitz et al. 2000; Bellmann et al. 2002), and they concentrate on differences between foreign (i.e., west German) establishments and east German establishments with respect to productivity. Direct indicators of technological capability are not a subject of their paper. The study of Belitz et al. is about the impact of foreign investors on competitive market structures in eastern Germany. Aspects of technological capability play a minor role, and west German investment is not a subject of their investigation.

3. For an overview of the theoretical approaches explaining multinational firms (not FDI as a macro variable), see, for example, Caves (1996), or Dunning (1993: 68).

4. Barz (1998), Autschbach (1997), Klagge (1997) and many others base their empirical research on the OLI paradigm.

5. Thus, the term "internalization" has nothing to do with external effects here. It simply means that certain technologies or know-how is being transferred internally, that is, within the multinational enterprise.

6. In September 1989, the threshold had been changed from 25 percent to 20 percent. It is reasonable to assume that these changes (from 25 percent to 20 percent and from 20 percent to 10 percent) cause problems when comparing German FDI stock data over time. But, according to the calculations of the Federal Bank, the changes have not caused much distortion, because most FDI was invested in 100 percent foreign-owned subsidiaries (Jost 1999: 131, 147).

7. The underestimation problem can occur the other way around, that is, foreign firms investing first into eastern Germany and subsequently creating establishments (local business units) in western Germany. However, it is more likely that FDI is underestimated in eastern Germany, because western Germany has a long tradition of FDI. On the difficulties of regional FDI data for eastern and western Germany, see also Votteler (2001: 142).

8. Accordingly, the terms "foreign establishment (firm)," "west German establishment (firm)," and "eastern German establishment (firm)" will be used in the empirical part of this paper.

9. For further methodical information about the IAB establishment panel, see Kölling (2000).

10. Several branches are dominated by a few big investments. In order to prevent data disclosure, figures often cannot be published for single branches.

11. Some of the CEECs had previously used higher thresholds; for example, Estonia applied a 20 percent threshold until the end of 1999, and Slovenia used a 50 percent threshold between 1997 and 1999. Consequently, FDI has been underestimated in comparisons with countries applying the 10 percent threshold.

12. Furthermore, eastern Berlin was not been taken into account because official statis-

tics do not allow for a breakdown between eastern and western Berlin. But even if Berlin were in its entirety included, which, in turn, would be an overestimation, eastern Germany (with $1,095 FDI per head) would still lag clearly behind the Czech Republic, Estonia, Hungary, and Slovenia.

13. For several years now, the OECD has sought alternative measures for multinational enterprises' activities. The OECD recommends the collection of survey data on foreign subsidiaries' real activities in the host economy, such as their proportion of investments, sales, employment, exports, R&D expenditures, and such. Most OECD countries provide these figures for recent years (see, e.g., OECD 2002).

14. The very concept of how to classify low-, medium-, and high-tech is subject to an ongoing debate (Carroli et al. 2000; Krockow 2002; OECD 1999). The discussion about a reasonable definition of high-tech first considers whether high-tech industries are industries that extensively produce or extensively use technology. The OECD classification takes into account both "the level of technology specific to the sector (measured by the ratio of R&D expenditure to value added) and the technology embodied in purchases of intermediate and capital goods" (Hatzichronoglou 1997: 3).

15. No major changes occur when conducting the low-, medium-, and high-tech classification on the basis of employment instead of on the number of establishments (Guenther 2004: 17).

16. In accordance with the Oslo Manual (OECD/Eurostat 1997) one should, however, bear in mind that market innovations only refer to the market of the relevant company and not necessarily to the world market as such.

17. Foreign and west German establishments could not be looked at separately because of the otherwise insufficient number of cases (projection requires at least thirty cases).

18. It would have been of interest to control for branch and firm-size structure simultaneously. Unfortunately, this was not possible because of an insufficient number of cases. The simultaneous control for branch and firm-size structure would require at least thirty cases in each branch/firm-size combination, which is not available, especially with respect to the firm-size class >500 and to branches that are less staffed.

19. For further information, see "Data Sources."

20. For the different types of product innovation, see Table 5.

21. The logistic regression aims at determining the most suitable model in order to describe the relationship between the binary dependent variable and a set of possibly differently scaled explanatory variables. This particular regression generates coefficients, and, additionally, its standard errors and significance levels, to predict the influence, that is, the positive or negative impact of the independent variables, on the probability of a company to innovate. For further information on the logic of logistic regression, see Pampel (2000: 1–18), and on the (negligible) differences between binary logit and probit regression models, especially concerning their estimation results, see Hartung and Elpert (1999: 133).

22. Yet, it has to be mentioned that the empirical evidence concerning the relation between firm size and innovativeness is ambivalent. Some studies indicate that a linear relation between firm size and innovativeness cannot be presumed—see, for example, Kamien and Schwarz (1985). Other empirical inquiries even suggest that such a relationship does not exist at all—see, for instance, Arvanitis (1997).

23. See Felder et al. (1996).

24. For a more detailed discussion, see Cohen and Levinthal (1990).

25. For further information, see Pavitt (1984: 356–365).

26. Due to problems of collinearity, the SUPDOM dummy has been left out of the regression procedure. To a certain extent, its effect on the dependent variable is captured by the constant term. Given that all constant impacts influencing a firm's probability to innovate are covered by this term, the particular impact of this dummy cannot be specified.

27. Akin to the chi-square tests, the Nagelkerke R^2 is commonly used to measure the

actual fit of a logistic model. It can be interpreted as an attempt to imitate a multiple R^2 based on likelihood. In principle, it compares the likelihood of a zero model, that is, a model that consists of the constant term only to the likelihood of the model estimated. Given that its maximum can reach a value smaller than 1, its interpretation turns out to be difficult. Therefore, the coefficient is divided by its maximum in order to create a measure that ranges from 0 to 1. For further information, see Nagelkerke (1991).

28. It is assumed that a firm's innovative capability is heavily determined by its absorptive capacity, which, in turn, is largely treated as a "function of the firm's level of prior related knowledge." (Cohen and Levinthal 1990: 128).

29. See Guenther (2004: 26).

30. Overall, one has to keep in mind the limitations inherent to this particular type of regression analysis. By virtue of the logic of logistic regression, the dependent variable is "only" binary and thus does not say anything in respect to the quality or the number of innovations carried out.

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Deutsches Institut für Wirtschaftsforschung; Institut für Arbeitsmarkt und Berufsforschung; Institut für Weltwirtschaft an der Universität Kiel; Institut für Wirtschaftsforschung Halle;

Zentrum für Europäische Wirtschaftsforschung (DIW Berlin/IAB/IfW/IWH/ZEW). 2003. "Zweiter Fortschrittsbericht wirtschaftswissenschaftlicher Institute über die wirtschaftliche Entwicklung in Ostdeutschland" [Second Progress Report by Economic Research Institutes about the Economic Development in East Germany]. Special Editions 7/2003. Halle Institute for Economic Research, Halle.

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