FDI and Domestic Investment

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February 2007

Abstract

Previous empirical work on the link between domestic and foreign investment provides mixed results which partly depend on the level of aggregation of the data. In this paper, we argue that the aggregated home country implications of foreign direct investment cannot be gauged by using firm-level data. Aggregated data, in turn, miss channels through which domestic and foreign activities interact. Instead, semi-aggregated data at the industry-level provide information on the linkages between domestic and foreign investment. Building on a theoretical framework that includes both input and output market linkages, we use data on German inward and outward FDI to assess the links between domestic and foreign investment. We find evidence for a positive long-run impact of FDI on the domestic capital stock.

Key words: foreign direct investment, domestic capital stock

JEL-classification: F21, F23, E22

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This paper has partly been written during visits of the authors to the research centre of the Deutsch Bundesbank. The hospitality of the Bundesbank as well as access to its firm-level database International Capital Links ('Midi') are gratefully acknowledged. The project has benefited from financial support through the German Science Foundation under the project "Multinational Enterprises: New Theories and Empirical Evidence from German Firm-Level Data" (BU 1256/6-1) and under SFB-TR 15. We would like to thank Johannes Becker, Clemens Fuest, Wolfram Schrettl as well as participants of seminars given at the ASSA Annual Meetings and at the University of Cologne for helpful comments on an earlier draft. Franziska Peter and Martin Schlotter have provided most efficient research assistance. All errors are in our own responsibility.

1 Motivation

Multinational activity of German firms has increased significantly in recent years. Between 1989 and 2004, the stock of FDI has increased from 2 to 8% compared to the total domestic capital stock, and German firms hold about twice as much capital abroad than foreigners hold in Germany. German firms have doubled the number of workers in their foreign affiliates from 2 to 4 million or the equivalent of 10% of the domestic workforce (Figure 1). Employment in affiliates of foreign firms in Germany has increased from about 1 to 1.5 million workers. The aggregated domestic capital and domestic employment, in contrast, have remained almost unchanged.

The labor market implications of increased foreign direct investment (FDI) have received much attention in the media and in academic research (see, e.g., Becker and Muendler 2006). The integration of countries in Eastern Europe and in Asia that are richly endowed with labor has given rise to concerns that persistent unemployment may be the result of increased FDI and that low-skilled labor in Germany is particularly affected.

As regards the long-run implications of FDI, the impact on the domestic capital stock is even more important. Yet, despite the importance of the capital stock for long-run production possibilities, there is relatively little empirical evidence on the links between domestic and foreign investment.[1]

In this paper, we use data at a semi-aggregated level that allow considering aggregate investment effects and channels of interaction between domestic and foreign investment. We contribute to the literature in two ways. First, we use a theoretical model that nests different types of multinational activity and that allows for input- and output-market linkages among industries. We use the model to derive implications on the aggregate investment effects of FDI. Second, we not only look at the link between FDI and the domestic capital stock but we break up domestic capital into the investment of domestic

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[1] In their survey of the home country effects of FDI, Barba-Navaretti and Venables (2004, Chapter 9) focus on the complementarity between domestic and foreign employment, and on the effects of FDI on technology and productivity.

and of foreign firms (inward FDI). This distinction allows being more precise with regard of the linkages between domestic and foreign capital. We estimate the links between domestic and foreign activities using data that are aggregated at the industry-level.

We are not the first to analyze the links between FDI and domestic capital. Instead, there are two strands in the existing empirical literature addressing this link. Feldstein (1995) uses aggregated data for the United States and finds a negative correlation between FDI and domestic investment. He regresses domestic investment on domestic savings and FDI. Hence, the paper looks at the aggregated consequences of FDI for domestic investment. Desai, Foley, and Hines (2005a) replicate this study using more recent data, and they confirm the negative relationship in aggregated data. For multinational firms, in contrast, they find a positive association between domestic and foreign investment.

A second strand of literature uses firm-level data, again mostly for the US. Desai, Foley, and Hines (2005b) use information on the investment of US multinationals link changes in different types of domestic activities of US multinationals to changes in the foreign activities of these firms. The model includes relatively few control variables but a full set of time fixed effects. They find a positive impact of FDI: firms that invest abroad also tend to invest more in the home economy.

For the US, the link between domestic investment and FDI differs in the aggregated and in the firm-level data. There are several possible reasons for this. First, across firms that invest abroad, the correlation between domestic and foreign investment need not be the same. Aggregation across different firms might cloud different adjustment patterns at the firm-level. Second, firm-level studies disregard the general equilibrium effects of FDI for the investment of other firms. If some firms engage in FDI, other firms in the same sector or region might be affected as well. Competition might become more intense; output and product market conditions for competitors, suppliers, and customers of firms engaging in FDI may change. And, third, the differences between studies at different levels of aggregation might simply be due to differences in the data used. Some studies use balance of payments data, while others use foreign direct investment stock statistics.

When comparing results from studies using aggregated and firm-level data, one also needs to bear in mind that these studies answer different types of questions. While using

firm-level data is of interest when testing specific partial-equilibrium effects of FDI, it is the aggregated employment or investment implications that are important from a macroeconomic and, not least, a perspective and, not least, for policy makers.

In this paper, we argue that both approaches used in the literature do not tell the full story about the linkages between FDI and the domestic capital stock. Aggregation across firms and industries does not allow shedding light on sources of complementarities between domestic and foreign investment. Using firm-level data does not allow analyzing feedback effects between different firms. Assessing the effects of FDI on domestic activities on the basis of firm-level data requires performing a counterfactual experiment (see Becker and Muendler (2006) or Kleinert and Toubal (2006) for evidence using German data). Using, for instance, matching models, one needs to find a group of 'comparable' non-treated firms and to associate the outcome (here: domestic capital) of the 'treated' firms (here: the FDI firm) to the outcomes of their 'neighbors' in the comparison group. By definition, such firm-level estimation procedures ignore the impact that FDI of some firms can have on other, *non-comparable* firms that are active in the same industry or region. For these reasons, we follow an intermediate route by using semi-aggregated data at the industry -level.

In Part 2, we lay out a theoretical model which provides the intuition for the linkages between the domestic and the foreign capital stock. In Part 3, we describe our data and present descriptive statistics. In Part 4, we present the more formal empirical analysis. Overall, we find evidence for a positive impact of FDI on the domestic capital stock. At the same time, effects differ in the short- and the long-run.

2 Theoretical Model

2.1 General Set-Up

In this section, we develop a theoretical framework to investigate how foreign investment[2] affects the domestic capital stock at the industry-level. For this purpose, we

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[2] Unless indicated otherwise, FDI or foreign investment denotes the *stock* of capital invested abroad.

distinguish foreign direct investment in three different industries: FDI that is carried out by firms in the industry under consideration, called industry *S*, FDI that is done by firms in industries that deliver inputs to industry *S*, called industry *I*, and FDI that is carried out by firms in industries that produce output with inputs received from industry *S*, called industry *O*.

To assess how FDI in these three different industries affects the domestic capital stock in industry *S*, we further need to distinguish three types of firms active on the home market: Purely domestic enterprises (PDE), domestic multinational enterprises (MNE), and foreign held enterprises (FHE). Purely domestic enterprises are owned by domestic owners, produce locally and serve only the domestic output market. Multinational enterprises are owned by domestic owners and operate (produce and sell) both domestically and abroad. Foreign held enterprises are owned by foreigners and operate both domestically and abroad. In our empirical analysis, we will be able to distinguish the domestic factor demand for capital of domestic companies (i.e. MNEs plus PDEs), and of foreign held companies (FHEs).

We describe firms by their production possibilities as captured in their production function. Thus, we do not consider in detail how a firm chooses to organize its production, as captured by the recent literature on the theory of the firm. Our reduced form of describing a firm allows focusing on the profitability effects arising from FDI. Desai, Foley, and Hines (2005b) likewise have a partial equilibrium model in which multinational firms simultaneously choose domestic and foreign inputs. Their focus is on the form of the production function and how it affects the complementarity between domestic and foreign capital. Our model, in contrast, focuses on the effects that changes in the activities of multinational firms have for domestic firms via changes in output prices and on the linkages between firms in different industries. To analyze this relationship we use a production function that captures the complementarity between domestic and foreign capital, as suggested by the empirical results of Desai, Foley and Hines (2005b).[3]

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[3] Results using data for German multinational suggest a positive relationship between foreign and domestic activies as well (see, e.g., Kleinert and Toubal 2006).

The production possibilities of the three types of firms, MNEs, PDEs and FHEs can be characterized as follows. Multinational firms produce for the domestic market with a production function $f(L,\widetilde{L},K,\widetilde{K})$ where $L(\widetilde{L})$ is labor employed domestically (abroad), $K(\widetilde{K})$ is capital invested domestically (abroad), and a ~ denotes foreign variables. This production function captures the idea that the MNE firm takes advantage of the possibility to locate part of its production abroad. Domestic firms are characterized by a production function $g(L,K)$. Finally, foreign held firms produce with a production function $h(L,\widetilde{L},K,\widetilde{K})$. Like MNEs, FHEs have access to foreign production opportunities. For notational convenience, we assume that all MNEs are completely symmetric and so are all PDEs and FHEs.

Throughout our analysis we use the following specifications of production functions for the domestic market:

$$\begin{aligned} f(L,\widetilde{L},K,\widetilde{K}) &= L^{\alpha_1}\widetilde{L}^{\alpha_2}K^{\beta_1}\widetilde{K}^{\beta_2} \\ g(L,K) &= L^{\alpha}K^{\beta} \\ h(L,\widetilde{L},K,\widetilde{K}) &= L^{\alpha_1}\widetilde{L}^{\alpha_2}K^{\beta_1}\widetilde{K}^{\beta_2} \end{aligned} \qquad (1)$$

To rule out economies of scale, we restrict to sum of the factor shares in the production function to $\sum\alpha+\sum\beta\le 1$.[4] We focus on the short- to medium-run, where the number of firms is exogenously given, but the firms choose inputs – including the capital stock – to maximize their profits. The total number of firms is normalized to 1. To simplify our analysis, we assume that all firms produce homogenous goods. Thus, the domestic product market is characterized by a demand function $p(X)$, where X is the total output produced by MNEs, FHEs and PDEs. The market price $p(X)$ adjusts such that the

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[4] This specification requires that multinational firms have non-zero inputs of foreign capital and labor. To rule out the possibility that a restriction of foreign activities would also jeopardize domestic production, we could use $L^{\alpha_1}\left(1+\widetilde{L}\right)^{\alpha_2}K^{\beta_1}\left(1+\widetilde{K}\right)^{\beta_2}$ as an alternative specification, this would leave our main results unaffected while making the exposition more cumbersome.

product market is cleared. All firms take the market price *p* as given, i.e. all firms behave as price takers.

We assume that MNEs, PDEs and FHEs maximize profits by choosing factor inputs, taking as given domestic (foreign) factor prices $w(\tilde{w})$ for labor and $r(\tilde{r})$ for capital. Due to restrictions in the mobility of labor, factor prices need not be equalized internationally. However, firms will choose their input demand such as to optimally take advantage of factor price differences. We take a partial equilibrium approach and do not take into account the impact of industries' factor demand on overall factor prices.

The profit functions of MNEs, FHEs and PDEs are given as

$$\begin{aligned} \pi_{MNE} &= \mathrm{p}(X)\, f(L,\tilde{L},K,\tilde{K}) \; - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} \\ \pi_{FHE} &= \mathrm{p}(X)\, f(L,\tilde{L},K,\tilde{K}) \; - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} \qquad (2) \\ \pi_{PDE} &= \mathrm{p}(X)\, f(L,K) \; - wL \; - rK \; . \end{aligned}$$

We start by investigating how factor demand reacts to changes in input and output prices. We then proceed to capturing the specific effects of foreign direct investments in different industries.

Lemma 1

Consider an increase in domestic output price *p,* due to an exogenous change in demand. Then all firms increase their factor demand for both *L* and *K*.

Proof: See Appendix

Lemma 2

Consider a decrease in the domestic input price *r*. Then all firms increase their factor demand for *K* and *L*.

Proof: See Appendix

Lemma 3

Consider a decrease in foreign input price $\tilde{w}$. Then MNE and FHE increase their factor demand for $\tilde{K}$ and for *K* whereas PDE decreases its factor demand for *K*.

Proof: See Appendix

2.2 Effects of Vertical and Horizontal FDI

For our analysis of how FDI affects the domestic capital stock we have to distinguish the motivation that is driving the foreign investment. An increase in the foreign capital stock could be driven by production cost considerations or by market seeking motivations. The first type of investment is called a vertical investment; the second type is called a horizontal investment. To fix ideas, we will capture these two motivations of investment by a change in foreign input prices, on the one hand, and by a change in output prices, on the other hand. So a vertical investment can be thought of as being motivated by a reduction in foreign input prices, for instance because of the integration of labor-rich countries of Eastern Europe and Asia into the world economy. A horizontal investment can be thought of as being motivated by an increase in foreign output prices, for instance because of the increased demand from the newly emerging markets or by a reduction in transaction cost that affects the net price available in foreign sales.

FDI originating from / FDI motivated by	Industry *S*	Industry *I*	Industry *O*
Lower foreign input prices (vertical FDI)	**Case 1** MNE and FHE experience reduction in $\widetilde{w}$	**Case 3a** MNE, PDE and FHE experience reduction in input prices	**Case 4a** MNE, PDE and FHE experience either decrease in *p* or increase in *p*
Higher foreign output prices (horizontal FDI)	**Case 2** MNE, PDE and FHE experience increase in *p* if output prices develop symmetri-cally at home and abroad	**Case 3b** No impact on MNE, PDE and FHE	**Case 4b** MNE, PDE and FHE experience increase in *p*

The effects of FDI on the home economy depend not only on the motive driving the foreign investment, but input and output sectors may also be affected differently. Recall that we intend to study FDI in three different industries. In each industry, FDI may be motivated by a change in input price or a change in output price in the foreign market where the investment takes place. Thus, there are six potential scenarios to be considered. The above table summarizes the implications of these six different scenarios from the point of view of firms in industry *S*.

Case 1: Effects of vertical FDI in the same industry

Consider first a vertical foreign investment that is driven by improved production opportunities abroad. We capture this effect by a change in the relative foreign input prices, in particular a change in $\tilde{w}$ while keeping $\tilde{r}$ constant. Without loss of generality, we restrict attention to MNEs and PDEs for this purpose. The total number of firms is normalized to 1, and the share of MNEs and PDEs is given by q and (1-q) respectively. Thus, total output is $X = qf + (1-q)g$.

From Lemma 3 above we know that a decrease in the foreign price for labor, $\tilde{w}$, induces an MNE to increase its employment of labor and hence, due to the positive cross derivatives of the production function also the foreign and the domestic capital stock of the MNE. This leads to an increase in domestic production and hence a lower market clearing price p. From Lemma 1, however, we know that a decrease in p reduces factor demand. This is why PDE uses less labor and less capital. The overall effect is summarized in the following result.

Result 1

Consider a decrease in foreign labor price, $\tilde{w}$.

- The domestic capital stock *K* by MNEs increases and
- The domestic capital stock *K* by PDEs decreases.

The overall effect on the domestic capital stock depends on the price effect on the domestic product market and is more likely to be positive

- The larger the share of MNEs, q
- The less price elastic product demand

Proof: See Appendix.

Thus, the overall effect depends on how strong the negative price effect is and how large the share of MNEs and PDEs in the overall market is.

Of course, total production for the home market cannot decrease. If this were the case, domestic output price would increase and so would the production by PDEs. But due to the increase in competitiveness of MNEs, production by PDEs is to some extent replaced by production by MNEs. Since MNEs produce with both foreign and domestic capital, total domestic capital may decrease even though total domestic plus foreign capital increases.

How would FHEs be affected in this case of vertical investment? If they benefit from improved production opportunities like MNEs, they should react like MNEs with an increase in production and domestic input demand. If instead they are not able to benefit from the same cost advantage, they should react more like PDEs, i.e. reduce their domestic capital stock due to the negative price effect.

Case 2: Effects of horizontal FDI in the same industry

We interpret horizontal foreign investment as being driven by an increase in foreign market size. This could be due to either a symmetric increase in world market size or an asymmetric increase in just the foreign market size. This change in market size should affect domestic production and input demand only if the domestic market size changes as well. The more symmetric the increase in market size, the more likely it is to experience a positive impact on the domestic market.

To fix ideas we capture the change in market size by a change in the output price. This has the following impact:

Result 2

Consider an increase in both foreign and domestic market prices. Then domestic capital investments by MNEs, PDEs and FHEs increase. The smaller the domestic price increase, the less likely is an increase of domestic capital investments.

Proof: See Appendix

Case 3: Effects of FDI in input industries

We consider next foreign investment that is undertaken by firms in the industry delivering inputs to industry *S*. If this investment is motivated by output price changes (Case 3b), then there is no reason to expect an impact on industry *S*. If in turn the investment is motivated by input price changes (Case 3a), then this should imply that all firms in industry *S* experience a reduction in the input prices they use. We capture this by a reduction in the price for capital *r*. As shown in Lemma 2 we get the following result

Result 3

Consider FDI in the input industry that is motivated by lower input prices abroad. This leads to a reduction in capital price *r* for firms in industry *S* which in turn leads to an increase in the domestic capital stock.

Case 4: Effects of FDI in output industries

Finally, we turn to investments that are undertaken in the industry that is buying inputs from the industry under consideration. If this investment is driven by an input price reduction abroad (Case 4a) and if this input is a substitute for the input produced in the industry under consideration, then this will be reflected by a reduction in output prices for the industry under consideration. If instead the investment abroad is motivated by changes in price from inputs that are complementary to the input produced by the industry under consideration, or if the investment is motivated by an increase in output prices abroad (Case 4b), then this would be reflected by an increase in output prices. As shown in Lemma 1 this leads to the following results.

Result 4

Consider FDI in the output industry that is motivated by lower input prices abroad. If the inputs are substitutes for the inputs produced in industry *S*, firms in industry *S* experience a reduction in output price *p* and hence reduce their domestic capital stock. If the inputs are complements or if the FDI in the output industry is motivated by higher output prices abroad, firms in industry *S* experience an increase in output price *p* and hence increase their domestic capital stock.

In sum, our theoretical model has a couple of testable implications:

First, the home country effects of FDI in any particular industry depend on the motive that drives the foreign investment as well as on the industry from which this foreign investment originates.

Second, market seeking, horizontal investment tends to have a positive impact, production cost motivated, vertical investments can have both a positive or a negative impact. Positive effects of vertical FDI are more likely the less price elastic industry demand and the larger the share of multinational firms in this industry.

Third, FDI in industries supplying inputs tend to have a positive impact on the domestic capital stock whereas FDI in the industry to which output is supplied can have a positive or a negative effect.

3 Data and Descriptive Statistics

The theoretical model outlined above stresses implications of FDI for the domestic economy that differ across industries. Here, we describe the data that we use to test the predictions of this model.

3.1 Data on Foreign Direct Investment

We use the firm-level database *MiDi* (Micro database Direct Investment, formerly 'International Capital Links') provided by the *Deutsche Bundesbank*. For details on the *MiDi* database see Lipponer (2006). From this source, we create a semi-aggregated datasets by the industrial sector of the parent.

At the industry-level, we use standard NACE sectors which allow combining our FDI data with industry-level data obtained from the German Statistical Office. The original *MiDi* database contains information on more than 100 industries, following NACE Rev. 1 categories, and these can be aggregated into 37 broader industries. Of these, we use only standard manufacturing and services industries. We drop industries such as agriculture, mining and quarrying, public institutions, or households. Out of the industries dropped, holding companies are particularly important. The final set of industries includes 13 manufacturing and 9 services industries.

Additionally, we eliminate changes in our dependent variables which are due to changes in reporting limits by dropping all observations that are not covered by the most stringent reporting requirements. Overall, we delete about 60% of the number of firm-level observations (see Table 1). The loss of observations is less severe for the total volume of activities since we drop the smaller units. The mean size of foreign affiliates increases moving from the full to the restricted sample by about 40%. For outward FDI, this increase is relatively uniform across the size measures used (affiliate sales, affiliate employment, and volume of FDI). For inward FDI, affiliate sales and employment increase by about 40% while the mean volume of FDI is almost unchanged.

We create a dataset that contains four measures of multinational activity: (i) the volume of sales of foreign affiliates of German firms, (ii) the volume of FDI of foreign affiliates abroad, (iii) the number of affiliates of each industry that are active abroad, and (iv) the volume of employment in the foreign affiliate. The same type of information is obtained for affiliates of foreign firms in Germany.

In our theoretical model, we have stressed the importance of distinguishing vertically and horizontally-integrated multinationals. Empirically, we cannot directly distinguish between the two motivations of FDI, i.e. we cannot identify changes in foreign input prices or foreign output prices for each investment project. Instead, we split the data in two ways. First, we split the data into multinational activity with high-income countries, with low-income countries, and with accession states. Second, we split the data into cases where the parent and affiliate are active in the same industry (as a proxy for horizontal FDI) and into cases where parent and affiliate are active in different industries (as a proxy for vertical FDI). For this breakdown, we use the fine industry-level disaggregation contained in the data. This classification is possible only for outward FDI since we do not have information on the sector of the foreign parent.

3.2 Industry-Level Explanatory Variables[5]

The *MiDi*-database does not provide information on a number of control variables of interest. We obtain industry-level information from OECD's STAN database and from

[5] Details on the data specification and sources are given in the Appendix.

the German statistical office. From the OECD, we also obtain input-output tables for Germany. We use information for the year 1995 to construct weights for the inputs (outputs) each sector receives (delivers) from/to the other sectors. We use these (time-invariant) weights, together with information on the FDI of each sector, to construct a measure of the FDI on input (output) sectors. Using the industry-level regressions, we also include a dummy variable for the re-unification period which might also pick up some of the effects of the reclassification of industries described above.

Using industry-level data, we have to keep in mind that the Federal Statistical Office Germany changed industry classifications for the national accounts twice during the time-span of our sample-period from 1991 to 2004. Yet, the data that we use has een adjusted for these changes. We use the latest classification (WZ03) that is compatible with EU standard NACE Ref 1.1. which, in turn, is fully consistent with the ISIC Rev. 3 categories used in the STAN-data. Also, in the case of employment and hourly wages, we build on data from national accounts, which are compatible with International Labour Organization (ILO) standards.

3.3 Measuring Capital Stocks

Our main dependent variable is the domestic capital stock. Ideally, we would split up the domestic capital stock into the capital owned by purely domestic firms (PDE), by domestic multinationals (MNE), and by foreign multinationals (FHE). Unfortunately, we have no comprehensive dataset which would allow identifying all purely domestic and all domestic multinational firms. We therefore decompose the capital stock into the capital owned by all domestic and by foreign firms. We define the total capital stock as $K = K^D + K^{FHE}$, where K^{FHE} = stock of inward FDI, and K^D = domestic capital stock of domestic firms. We obtain the domestic capital stock owned by residents by subtracting the stock of inward FDI from the total capital stock. We measure inward and outward foreign direct investment using the *MiDi*-data and aggregating the data by industry. Data on aggregated capital stocks come from the German Statistical Office. Using these distinctions, we thus have the domestic capital stocks owned by residents and owned by non-residents (inward FDI) as dependent variables.

3.4 Measuring Industry Spill-Overs

One advantage of using industry-level data is that we can analyze the effect of FDI in other industries. Using industry-level input-output tables for Germany, we construct a weight of each industry in the inputs and outputs of other industries. Using these weights, we split up FDI into FDI in industries providing inputs and industries buying the outputs of industry *i*.

In our empirical model below, we thus include not only FDI in industry I but also FDI of input and output sectors denoting FDI_{it}^{inp} as the weighted amount of FDI that industry *i* „receives'' via inputs from other industries in year *t* and FDI_{it}^{outp} as the amount of FDI that is attributable to industry *i* via its output-links to other industries. We define $FDI_{it}^{inp} = \sum_k w_{kit} \cdot FDI_{kt}$, the weighted sum of FDI from all industries *k*, that deliver inputs to industry *i*. We calculate the weights as $w_{kit} = \frac{inp_{kit}}{\sum_k inp_{kit}} = \frac{inp_{kit}}{inp_{it}}$, the proportion of inputs that industry *i* receives from industry *k* relative to its total inputs, with $\sum_k w_{kit} = 1 = w_{it}$. We define $FDI_{it}^{outp} = \sum_k w_{ijt} \cdot FDI_{jt}$, the weighted sum of FDI from industries *j* that industry *i* delivers outputs to, where $w_{ijt} = \frac{outp_{ijt}}{\sum_j outp_{ijt}} = \frac{outp_{ijt}}{outp_{it}}$, with $\sum_j w_{ijt} = 1 = w_{it}$. This decomposition allows answering the question whether FDI in input and output industries has an impact on the domestic capital stock.

Recall from our theoretical considerations above that the impact of FDI in industry *i* on the domestic capital stock depends on the motive that drives the foreign investment. It is positive in case of market seeking investments, and it can be positive or negative in case of production cost motivated investments. In the latter case, it is more likely to be positive the less price elastic industry demand and the larger the share of multinational firms in this industry. A less price elastic demand reduces any potential negative pecuniary externality the increased productivity of multinationals may have on their

competitors. A larger share of multinational firms means that there is a smaller share of purely domestic firms that are potentially negatively affected.

We expect FDI in the industry from which industry *i* receives inputs to have a positive impact on the domestic capital stock. The effect of FDI in the industry to which industry *i* supplies outputs can be positive or negative, positive in case of a market seeking investment, positive or negative in case of a production cost motivated investment.

3.5 Descriptive Statistics

The past 15 years have witnessed an increasing globalization of the German economy, measured through the increase in FDI (both inward and outward) and in foreign employment. The capital stock owned by German firms abroad has increased from less than 2% of the total capital stock in 1991 to about 8% in 2003 (Figure 1a). The ratio of foreign to domestic employment is even higher (about 10%), which reflects the higher labor-intensity of foreign production. The domestic capital stock and in particular labor market performance has been much less dynamic, and the aggregated capital stock has remained almost unchanged. At first sight, these patterns in the data might suggest that the increasing globalization of the German economy has had little impact on the domestic economy.

4 Empirical Model and Regression Results

The theoretical model has shown that the impact of foreign direct investment on the domestic capital stock is not clear a priori. The impact depends on the input and output linkages between industries, on the price elasticity of output demand, on the importance of multinationals in each industry, and on the importance of horizontal and vertical FDI. In this section, we describe the empirical model that we estimate to gauge the effects of FDI on the domestic capital stock.

4.1 Empirical Model

The baseline empirical model that we estimate gives the response of the domestic capital stock to factors prices, employment, and output. We also include proxies for international openness:

$$K_{it}^{D} = \alpha_o + \beta_1 \left(\frac{w}{p} \right)_{it} + \beta_2 L_{it} + \beta_3 Y_{it} + \beta_4 OPEN_{it} + \varepsilon_{it} \qquad (3)$$

where $OPEN_{it}$ is a vector of openness variables, including inward and outward *FDI*, $(w/p)_{it}$ = real wages, L_{it} = employment, Y_{it} = output, ε_{it} = error term, i denotes the industry (or region), and t = time. Ideally, we would also include a proxy for the real interest rate. However, we are unaware of data that measures the interest at a sector level. Partly, differences in (real) interest rates across sectors are captured in the sector fixed effects. In contrast to Desai et al. (2005b), who do not control for the level of output and the alternative factors of production used, this specification estimates the effects of greater openness on the domestic capital stock *at a given scale of activities*.[6]

In our empirical analysis, we have to address two econometric problems. The first is the potential endogeneity of the regressors. We particularly need to address the endogeneity of the variables included in the vector $OPEN_{it}$. The second issue is the potential non-stationarity of the left-hand-side variable. We discuss the non-stationarity issues below (Section 4.3).

Turning to the endogeneity problem first, Desai et al. (2005b) propose using weighted foreign GDP growth as an instrument for the foreign variables. However, Harrison and McMillan (2006) argue that foreign GDP growth is a significant determinant of domestic variables (in their case employment) and thus propose using a set of exogenous foreign variables (GDP per capita, tariffs, education expenditures, telephone mainlines etc.). Their empirical strategy is similar to the two-stage empirical model proposed by Frankel and Romer (1999) who estimate the impact of trade on growth. At a first stage, a bilateral

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[6] See Hanson et al. (2003) for a similar specification using the demand for labor as the dependent variable.

openness equation is estimated, which explains the level of bilateral economy activity between industry *i* and a foreign country *j* by the following gravity-type equation:

$$\tau_{ijt} = a_0 + a_1 X_{ij} + a_2 X_{it} + a_3 X_{jt} + \varepsilon_{ijt} \qquad (4)$$

where τ_{ijt} is a measure of bilateral openness, X_{ij} is a set of time invariant bilateral explanatory variables, X_{it} is a set of (potentially time-varying) explanatory variables for industry *i*, and X_{jt} is a corresponding set of explanatory variables for the foreign country *j*. This equation is estimated using a pooled OLS regression with robust standard errors, including a full set of time fixed effects. At a second stage, the predicted values from equation (4) are used to construct instruments for FDI which are related to exogenous geographic variables only. Re-writing (4) in matrix form $\tau_{ijt} = \mathbf{a}'\mathbf{X}_{ijt} + \varepsilon_{ijt}$ where $\mathbf{a}$ is the vector of coefficients and $\mathbf{X}_{ijt}$ is the vector of right-hand-side variables, industry *i*'s overall openness is given by

$$\hat{\Gamma}_{it} = \sum_{j \neq i} e^{\hat{\mathbf{a}}\mathbf{X}_{ijt}} \; . \qquad (5)$$

The explanatory variables included in (5) are exogenous to investment of industry *i*. This implies that predicted openness can be used as an instrument in an investment regression if predicted openness and actual openness are sufficiently correlated. We use the approach proposed by Frankel and Romer (1999) to account for the endogeneity of regressors in empirical models using the change in investment as the dependent variable.

4.2 Regression Results I: Gravity Equations

Our empirical model is based on the estimation of equations (3) and (4) above. We begin by reporting the results of the gravity equations for openness and then turn to the determinants of the domestic capital stock. Results for the gravity equations are given in Table 2. Results from these regressions not only serve as in input for our main empirical model. With the help of these regressions, we also obtain an indicators of the relative importance of the market-seeking and the production-cost motive for the internationalization of production.

The basis for estimating the gravity equations (4) is a dataset which aggregates the data across industries, foreign countries, and years. The gravity regressions are run for the different types of activities of multinational activities and splitting the data along different dimensions (high-income versus low-income countries etc.). These regressions are estimated using a pooled OLS estimator with robust standard errors, and including a full set of industry and time fixed effects. Results are fairly standard and follow the empirical literature on FDI.[7] We find a negative impact of distance and a positive impact of GDP per capita. For the (unreported) regressions that create the predicted values of FDI, we do not take logarithms of the data but rather estimate the baseline equation in levels. We do this as we need to aggregate the data across host countries. We allow for industry-specific effects of each of the explanatory variables (distance, GDP, population).

4.3 Regression Results II: Investment Equations

We estimate our main model of interest, equation (3), on a second dataset which aggregates the data across industries and years. This dataset is a largely balanced panel for 13 years (1991-2003) and 24 industries, respectively. We run the investment equation using two different dependent variables: the domestic capital stock owned by domestic residents[8] and the stock of inward FDI (both in logs).

As explanatory variables, we use employment, wages per capita, real value added, and inward and outward multinational activity. Multinational activity is captured through the volume of inward and outward FDI and the number of firms in each industry. The reason for distinguishing between the volume of activity and the number of firms is that we want to capture both the extensive and the intensive margin of multinational activity. All variables are in logs, and the coefficients can be interpreted as elasticities.

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[7] In addition to these more-or-less standard regressors, we also experiment with alternative regressors proposed by Harrison and McMillan (2006). These regressors do reasonably well. However, we do not use them to create the predicted values since data are not available for all countries, and we thus lose quite a significant amount of observations.

[8] The domestic capital stock is computed as the difference between the total domestic capital stock and the stock of inward FDI. For the sake of brevity, we will use the term ‘domestic capital stock’ in the following.

When using the capital stock as a dependent variable, the potential non-stationarity of the data becomes an issue. Our model is a fairly typical macro-panel with a similar dimension of the cross-section $i = 24$ and the time series $t = 13$. Ignoring non-stationarity of the data may thus lead to spurious regressions, as in time series data.

In a first step, we run panel unit root tests to check whether our dependent variable might be non-stationary. The results of these tests, which are reported in Table 3, are mixed. Moreover, panel unit root tests can be biased against finding evidence for unit roots if the cross-sections are cointegrated, i.e. if developments across industries are affected by a common trend (Banerjee, Marcellino, and Osbat 2005). In the following, we therefore proceed under the assumption that our main dependent variables are non-stationary.

We have two options for dealing with non-stationary data. One option is to first difference all data and to estimate the model in growth rates rather than levels. This method has the advantage that the dependent variable is stationary but it has the disadvantage that information on the long-run relationships among the variables of interest is lost. Essentially, such a model explains the short-run variation of changes in the capital stock and changes in inward FDI, but it does not give their long-run determinants. The second method that can be used to estimate the long-run relationships between domestic and foreign variables is to test for cointegration among the variables of interest and to estimate the long-run cointegration coefficients. In the following, we present results using both, the changes and the levels of FDI and the domestic capital stock as dependent variables.

4.3.1 Short-Run Dynamics

Table 4 presents regression results using the growth of the domestic capital stock and of inward FDI as the dependent variable. All regressions are estimated using a panel fixed effects estimator with robust standard errors to correct for autocorrelation and heteroskedasticity in the residuals. In addition, we present results using an instrumental variable estimator, which takes the endogeneity of the regressors into account. We instrument all variables with their own first lag. For our measures of FDI, we alternatively use the predicted value of the gravity regressions as instruments.

All regressions are estimated without time fixed effects. The reason for not including time fixed effects is that these would eliminate the general trend in the data. Our equations would explain the idiosyncratic deviations of the growth rates from these trends. In unreported regressions, we have checked the sensitivity of our results by including time fixed effects. Some of the explanatory variables such as employment, value added, and wages become insignificant in these regressions, suggesting that these variables in fact pick up trends in the data that are common to all cross-sections. Our main results for the impact of FDI are unaffected by including time fixed effects.

Turning to the results for the growth in the domestically-owned capital stock first, which are reported in Table 4a, we find positive effects of employment and wage growth. The elasticity of investment with regard to employment is about 0.2, the elasticity with regard to wages is about 0.4. The IV estimates yield higher elasticities. The impact of output growth is insignificant. These results are not affected by adding different measures of FDI (inward and outward FDI, both in terms of volume and number of firms) as regressors. The impact of FDI growth tends to be negative. Whereas the impact of outward FDI is insignificant, the negative impact of inward FDI is statistically significant at the 5%-level.

Splitting the sample into the manufacturing and the services sectors shows that the positive elasticity of investment with regard to wages is similar across sectors (results not reported). The significant elasticity with regard to employment is driven by the services sectors. In both samples, we confirm the negative impact of inward FDI growth on the growth in the domestic capital stock, but the effects are not always significant in the sub-samples. This shows that the significantly negative impact in the full sample is partly driven by the differences between the manufacturing and services sectors.

We also estimate the same set of regressions using the change in inward FDI instead of domestic capital stock as the dependent variable. Results are given in Table 4b. Growth in the domestic capital stock is added as an additional explanatory variable, but the main results are confirmed also by regressions excluding growth of the domestic capital stock. The link between growth in inward FDI and our standard control variables is weak. If anything, there is a positive impact of growth in value added. The growth of the domestic

capital stock has a negative and highly significant impact. The estimated elasticity is very high (–3) though. In contrast to the results for domestic capital, we now find a positive and significant impact of growth in outward FDI (both in terms of volume and in terms of the number of firms investing abroad) on inward FDI. This positive impact is robust across the different estimation methods used, in particular for the count variable.

4.3.2 Cointegration Tests and Long-Run Determinants of Investment

Results reported so far inform us about the short-run dynamics of domestic and foreign investment but not about the long-run relationships between the stock of FDI and the stock of domestic capital. We therefore test for the presence of a long-run cointegration relationship among our variables of interest by estimating a cointegrated panel model (Breitung 2005). The presence of a cointegration relationship is tested using a two-step estimator. For a VAR(1) model, the cointegrated model has the following VECM representation:

$$\Delta y_{it} = \alpha_i \beta' y_{i,t-1} + \varepsilon_{it} \qquad (6)$$

with $t = 0,1,\ldots,T$ and $i = 1,\ldots,N$, $E(\varepsilon_{it}) = 0$, $\sum_i = E(\varepsilon_{it}\varepsilon'_{it})$. This specification requires the long-run cointegration relationship (β) to be identical across cross-sections while the loading coefficients and thus the speed of adjustment (α_i) varies for each cross-section observation.

Estimating equation (6) proceeds in two steps. In a first step, the matrix β is estimated based on a consistent estimator of the short-run parameters α_i and of $\sum_i$. As $T \to \infty$, such consistent estimator of α_i can be obtained by estimating separate models for each cross-section unit *N*. At this stage, the restriction that the cointegration vectors are the same over the cross-sections is ignored. In a second step, the cointegration matrix β can be estimated by running an OLS regression on the pooled regression.

Since the cointegration estimator requires a balanced panel, we delete all cross-sections which have incomplete time series for the main variables of interest. This leaves us with a sample of $T = 13$ and $N = 21$.

Our model explains about two thirds of the variation in the domestic capital stock and FDI across industries. The explanatory power for inward FDI increases significantly as we add outward FDI as a regressor. Also, our results support the presence of cointegration relationships among the variables of interest (Table 5). The only exception are some specifications for the domestic capital stock at the industry-level and using tests for panel cointegration which do not allow for cross-section heterogeneity.

We present estimates for the long-run cointegration coefficients using four different specifications: an OLS model, a fully modified OLS regression (FMOLS), a dynamic OLS regression (DOLS), and the two-step estimator proposed in Breitung (2005). Both, the FMOLS and the DOLS estimator, address serial correlation and endogeneity of the regressors. The FMOLS estimator corrects the OLS estimator non-parametrically, while the DOLS estimator uses information from past and future leads and lags of all variables. Turning to the results at the industry-level first (Tables 6a and 6b), we find a positive effect of employment and wages on the domestic capital stock. The employment and wage elasticities are estimated relatively consistently across the different specifications (around 0.40), with a somewhat greater range for the wage elasticities. The impact of output is positive. Both, the stock of inward and of outward FDI have a positive effect on the domestic capital stock, but the elasticities are small (0.04).

Splitting inward and outward FDI along different dimensions (results not reported) gives no clear answer to the question whether market-access-driven or production-cost-driven FDI is behind this result. On the one hand, outward FDI into different sectors (one proxy for vertical FDI) has a positive impact on the domestic capital stock. On the other hand, outward FDI into high income countries (one proxy for horizontal FDI) has a positive effect as well. As regards inward FDI, FDI into different sectors and from high income countries have a positive impact on the domestic capital stock.

We also look at the impact of profitability on the domestic capital stock, and we interact profitability with inward and outward FDI. Entering profitability (operating profits relative to value added) separately gives a negative sign. Also, the interaction term between profitability and inward and outward FDI comes in with a negative sign.

Inward FDI also reacts positively to outward FDI, but the estimated elasticity is much higher than for the domestic capital stock (around 0.50) (Table 6b). The different measures for FDI (same sectors, different sector, high-income countries) all have a positive impact. The main difference between the regressions for inward FDI and the domestic capital stock is the effect of the control variables. Employment has a negative impact on inward FDI, and the impact of wages differs across specifications. In the baseline equations, the effect of wages is positive as well, but it turns negative in some specifications if we additionally use FDI measures as regressors. The elasticity of inward FDI with respect to output is positive and significant with an elasticity close to one. The link between inward FDI and the domestic capital stock is positive and significant as well.

5 Summary

What are the effects of the increasing activities of multinational firms on the home economy? Much of the earlier literature addressing the home-country effects of FDI stresses labor market implications, and many papers use firm-level data. The focus of this paper is on the longer-run implications of FDI on the domestic capital stock. We use data at a semi-aggregated level which allows studying effects of FDI at an industry- level.

Our theoretical model has shown that the impact of FDI on domestic investment in any particular industry depends on the motive that drives the foreign investment as well as on the industry from which this foreign investment originates. Market seeking investment tends to have a positive impact, production cost motivated investments can have both a positive and a negative impact. In the latter case, it is more likely to be positive the less price elastic industry demand and the larger the share of multinational firms in this industry. FDI in the industry from which inputs are bought tend to have a positive impact on the domestic capital stock whereas FDI in the industry to which output is supplied can have both a positive and a negative effect.

Our empirical results based on a detailed dataset on German FDI can be summarized as follows.

First, in the long-run, the effect of FDI on the domestic capital stock across industries is positive. This holds for both, the capital stock owned by domestic investors and the stock of inward FDI.

Second, the short-run link between the domestic capital stock and the stock of FDI is more mixed. Growth in inward FDI has a negative impact on the domestic capital stock whereas outward FDI has no significant impact. The positive impact of outward FDI on inward FDI found in the long-run is also present in the short-run.

Third, splitting FDI into different industries gives no clear-cut picture with regard to the impact of FDI driven by market-access considerations and FDI driven by cost considerations.

Overall, our results are evidence of the impact that the activities of multinationals have on the relative shifts across industries. While, at the aggregated level, increasing activities of German firms abroad and – to a somewhat smaller degree – of foreign firms in Germany have been associated with relatively stable patterns of the capital stock and employment, differences across industries are quite distinct. Overall, industries that have invested more abroad have, in the longer run, also increased their domestic capital stock.

6 References

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7 Data Definitions and Sources

FDI (inward and outward): Measures of FDI at the industry- -level are obtained from the firm-level database Micro-Database Direct Investment (MiDi), provided by the Deutsche Bundesbank. The data are confidential and can be used on the premises of the Deutsche Bundesbank only. We clean the data in several ways in order to account for changes in the reporting limits and to eliminate allocated sectors. For details see Section 3.1 in the main text. Details on the database are given in Lipponer (2006).

Industry-level data

The following data are for the year 1991-2003 and are taken from the OECD's Stan database (http://www.oecd.org/) and the Genesis database by the German Statistical Office (http://www.destatis.de/).

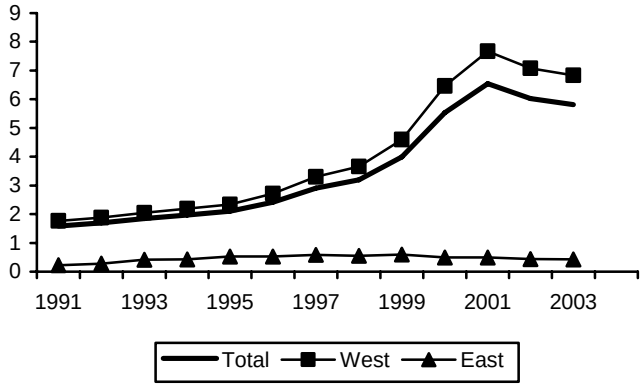
- Real gross value added Bruttowertschöpfung (2000 = 100), Code PRO013
- Gross wages in million € , 1991-2003, Code VST005
- Number of employess in 1000 (headcounts), 1991-2003, Code ERW005
- Exports by manufacturing , 1991-2003, OECD Stan Database
- Imports by manufacturing sector, 1991-2003, OECD Stan Database
- Gross capital stock (Nettoanlagevermögen) in constant prices of 2000 in million €, Code VGR074-VGRANLART01
- Number of employees (Arbeitnehmer) in 1000 (used to compute hourly wages), Groningen 60-Industry Database *

The following data are taken from the Groningen 60-Industry Database (Groningen Growth and Development Centre, 60-Industry Database, October 2005, http://www.ggdc.net/.)

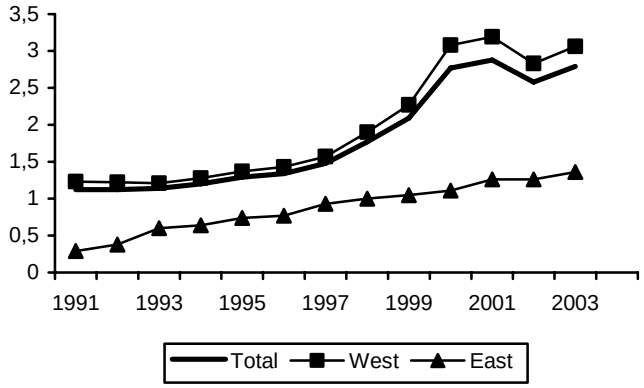
- Hours worked per annum
- Labor costs per employess (Arbeitskosten pro Arbeitnehmer)

Figure 1: FDI and Foreign Employment in % of Total

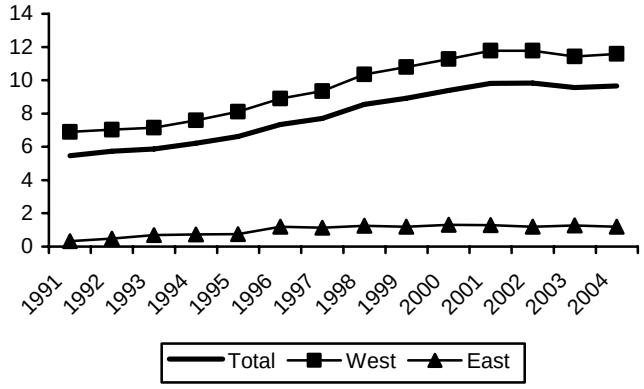
(a) Stock of outward FDI in % of domestic capital stock



(b) Stock of inward FDI in % of domestic capital stock



(c) Employment in foreign affiliates of German firms in % of domestic employment



(d) Employment in German affiliates of foreign firms in % of domestic employment

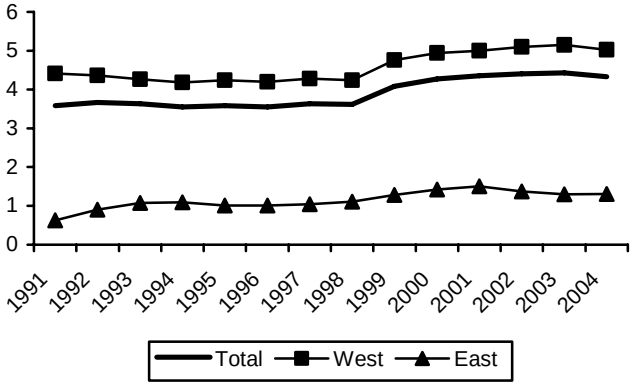


Table 1: Descriptive Statistics Full Versus Reduced Sample

This Table compares the full sample to the sample from which the industries Agriculture, Education and health, General government, Holdings, International organizations, Mining and quarrying, Non-profit organizations serving households, Other, Other community and social services, Other service activities, Private households, Recreational activities, and Sewage and refuse disposal have been removed. In addition, stricter reporting requirements which have been applied in later years of the sample period have been applied backward.

(a) Outward FDI (*K3*)

Variable	Observations	Mean	Standard Deviation
Full sample			
Affiliate sales (*pk04*)	411,181	32,322	379,791
Affiliate employment (*pk05*)	411,181	132	957
Volume of FDI (*pdum1*)	356,946	15,598	227,354
Restricted sample			
Affiliate sales *(pk04*)	175,672	46,054	539,807
Affiliate employment (*pk05*)	175,672	186	1,277
Volume of FDI (*pdum1*)	159,150	20,239	290,422

(b) Inward FDI (*K4*)

Variable	Observations	Mean	Standard Deviation
Full sample			
Affiliate sales (*pk04*)	252,249	33,972	288,401
Affiliate employment (*pk05*)	252,249	107	689
Volume of FDI (*pdum1*)	210,885	13,825	159,361
Restricted sample			
Affiliate sales (*pk04*)	103,219	47,053	335,237
Affiliate employment (*pk05*)	103,219	137	887
Volume of FDI (*pdum1*)	92,202	13,368	72,750

Table 2: Gravity Equations

This Table reports results of gravity regressions. A full set of time and industry-fixed effects is included in all regressions. Regressions are run as pooled OLS regression using robust standard errors. T-values are given in brackets. *** (**, *) = significant at the 1% (5%, 10%)-level.

	Total FDI	FDI same sector	FDI different sector	FDI without trade	FDI high income	FDI low income	Total Employment	Employment low income
Log distance	–0.43***	–0.34***	–0.39***	–0.37***	–0.49***	–0.37***	–0.48***	–0.50***
	(13.07)	(8.70)	(11.43)	(9.86)	(12.54)	(6.97)	(14.08)	(8.75)
Log real GDP	0.81***	0.69***	0.77***	0.69***	0.45***	0.86***	0.45***	0.63***
	(23.06)	(17.30)	(20.87)	(18.11)	(3.18)	(12.63)	(12.10)	(7.80)
Log population	–0.20***	–0.15***	–0.26***	–0.15***	0.25	–0.31***	0.19***	–0.05
	(5.51)	(3.45)	(6.45)	(3.83)	(1.64)	(4.88)	(4.80)	(0.74)
Constant	–14.07***	–11.94***	–12.66***	–10.97***	–11.70***	–11.10***	–7.94***	–5.89***
	(17.03)	(13.86)	(12.18)	(12.85)	(7.22)	(11.01)	(7.99)	(4.19)
Observations	12,790	10,466	8,964	11,405	6,703	6,087	12,468	5,949
R-squared	0.47	0.4	0.42	0.4	0.52	0.33	0.39	0.3

Table 3: Panel Unit Root Tests

This Table reports the test statistics of panel unit root tests based on Levin, Lin, and Chu (2002), and Im, Pesaran, and Shin (2003). The Null-Hypothesis is that the series contain a unit root. The maximum lag length was set at 8 quarters, basing the automatic lag selection on the SIC criterion. Newey-West bandwidth selection uses a Bartlett kernel. All variables are in logs. *** = significant at the 1%-level.

Variable	Observations	Cross sections	Levin, Lin, Chu	Im, Pesaran, Shin
Levels				
Domestic capital stock	273	24	–16.08***	–8.25***
Employment	393	33	–22.10***	–10.25***
Real value added	152	12	–2.95***	–0.09
Inward FDI (volume)	301	25	–5.40***	–1.79**
Outward FDI (volume)	302	25	–1.10	0.21
First Differences				
Domestic capital stock	251	24	–5.13***	0.02
Employment	369	33	–10.75***	–2.81***
Real value added	142	12	–8.29***	–4.36***
Inward FDI (volume)	284	25	–12.37***	–6.11***
Outward FDI (volume)	282	25	–9.52***	–3.84***

Table 4: Industry–Level Regression Results

In panel (a), the change in the domestic capital stock owned by domestic residents is the dependent variable. In panel (b), the change in the volume of inward FDI is the dependent variable. All variables are entered as first differences of their logs. Unification is a dummy variable which is equal to 1 for the years 1991-1994. All regressions are fixed effects panel estimators using robust standard errors clustered at the industry-level. *** (**, *) = significant at the 1% (5%, 10%)-level.

(a) Change in the domestic capital stock

	(1)	(2)	(3)	(4)	(5)
Δ log employment	0.21***	0.21***	0.21***	0.22***	0.21**
	(2.86)	(2.93)	(2.82)	(2.83)	(2.76)
Δ log real value added	0.02	0.04	0.03	0.03	0.03
	(0.57)	(0.90)	(0.65)	(0.61)	(0.66)
Δ log wages per capita	0.41***	0.39***	0.41***	0.41***	0.41***
	(11.5)	(8.46)	(11.3)	(11.9)	(11.3)
Δ log volume inward FDI		–0.03**			
		(–2.38)			
Δ log volume outward FDI			0.00		
			(–1.37)		
Δ log inward count				–0.02**	
				(–2.58)	
Δ log outward count					–0.01
					(–0.94)
unification	0.04***	0.04***	0.04***	0.05***	0.04***
	(12.9)	(13.0)	(12.8)	(13.2)	(12.9)
Constant	0.01***	0.01***	0.01***	0.01***	0.01***
	(5.05)	(5.76)	(5.02)	(5.29)	(5.05)
Observations	280	280	279	280	279
Number of groups	24	24	24	24	24
Adjusted R^2	0.52	0.6	0.52	0.54	0.52

(b) Change in inward FDI

	(1)	(2)	(3)	(4)	(5)
Δ log domestic capital stock	–5.55***	–5.38***	–5.20***		
	(–4.80)	(–4.62)	(–4.58)		
Δ log employment	1.15*	0.92	0.93	–0.23	–0.18
	(1.75)	(1.60)	(1.60)	(–0.46)	(–0.30)
Δ log real value added	0.60***	0.44**	0.36*	0.30*	0.21
	(3.47)	(2.28)	(1.78)	(1.78)	(1.44)
Δ log wages per capita	1.79	1.57	1.43	–0.63	–0.7
	(1.71)	(1.61)	(1.45)	(–0.85)	(–0.96)
Δ log volume outward FDI		0.17		0.18	
		(1.48)		(1.69)	
Δ log outward count			0.45***		0.48***
			(3.19)		(3.98)
unification	0.21**	0.21**	0.19**	–0.03	–0.04
	(2.70)	(2.51)	(2.33)	(–0.54)	(–0.60)
Constant	0.12***	0.11***	0.11***	0.08***	0.08***
	(7.94)	(7.91)	(8.18)	(7.99)	(7.99)
Observations	280	279	279	279	279
Number of groups	24	24	24	24	24
Adjusted R^2	0.18	0.21	0.29	0.05	0.15

Table 5: Panel Cointegration Tests

This Table presents results of the panel cointegration tests proposed by Kao (1997) and Pedroni (1995). Kao's (1997) tests DF_ρ and DF_t are based on the assumption of strong exogeneity of the regressors and errors; DF_ρ^* and DF_t^* are based on the assumption of endogeneity of regressors and errors. The H_0 hypothesis is 'no cointegration'. Pedroni's tests allow for heterogeneity in the cointegration relationships and are based on the H_0 of no cointegration as well. The regressions equations include employment, wages, output, and inward or outward FDI.

Dependent variable FDI measure	Domestic capital stock Outward	Domestic capital stock Inward	Stock of inward FDI Outward
DF_ρ	–0.09	–0.04	–5.47***
DF_t	–0.54	–0.29	–4.15***
DF_ρ^*	–4.20***	–4.23***	–9.48***
DF_t^*	–2.18**	–2.00**	–4.93***
$t_{\hat{\rho}NT}$	–167.78***	–150.97***	–150.26***
$t_{N1\rho}$	–17.15***	–17.19***	–20.11***
$t_{N2\rho}$	–16.48***	–16.52***	–19.31***

Table 6: Long-Run Cointegration Coefficients

This Table present estimates for the long-run cointegration parameters using a fully modified OLS estimator, a dynamic OLS estimator, and the two-step estimator proposed by Breitung (2005). *, **, *** = significant at the 10%, 5%, 1%-level. Results are based on a sample with $N = 21$ and $T = 13$.

(a) Domestic Capital Stock

	FMOLS (1)	DOLS (2)	Two-Step (3)	FMOLS (4)	DOLS (5)	Two-Step (6)
Employment	0.44***	0.40***	0.44***	0.38***	0.34***	0.39***
	(5.93)	(4.43)	(9.05)	(5.08)	(3.70)	(7.38)
Wages	0.49***	0.23***	0.64***	0.40***	0.22***	0.56***
	(7.58)	(2.93)	(14.95)	(5.45)	(2.51)	(10.32)
Output	0.16***	0.10	0.16***	0.18***	0.14*	0.24****
	(2.65)	(1.44)	(4.03)	(2.91)	(1.83)	(5.88)
Inward FDI	0.05***	0.04***	0.03***			
	(3.23)	(2.48)	(2.74)			
Outward FDI				0.04***	0.03**	0.02***
				(3.04)	(1.88)	(2.72)
R^2	0.62	0.68		0.62	0.67	

(b) Inward FDI

	FMOLS (1)	DOLS (2)	Two–Step (3)	FMOLS (4)	DOLS (5)	Two–Step (6)
Employment	–0.88***	–1.42***	–0.90***	–1.22***	–2.05***	–1.25***
	(–2.38)	(–3.23)	(–3.47)	(–3.12)	(–4.38)	(–4.55)
Wages	0.37	0.04	0.11	0.14	0.06	–0.60*
	(1.04)	(0.10)	(0.43)	(0.31)	(0.12)	(–1.90)
Output	0.97***	1.34***	1.04***	0.81***	0.80***	1.01***
	(3.25)	(3.75)	(5.16)	(2.65)	(2.20)	(5.11)
Domestic capital stock				0.85***	2.12***	0.76***
				(2.33)	(4.84)	(2.48)
Outward FDI	0.48***	0.56***	0.49***	0.45***	0.50***	0.51***
	(7.27)	(7.01)	(10.33)	(6.86)	(6.35)	(11.06)
R^2	0.53	0.60		0.51	0.66	

8 Mathematical Appendix

Proof of Lemma 1

Consider a PDE that maximzes the following profit function

$$\pi_{PDE} = pg(L,K) - wL - rK \tag{1}$$

The first order conditions for profit maximization are

$$\pi_L = pg_L - w = 0 \tag{2}$$

$$\pi_K = pg_K - r = 0 \tag{3}$$

To determine how PDE reacts to changes in p note that

$$\frac{dK}{dp} = \frac{|f_{Kp}|}{|F|} \tag{4}$$

where

$$F = \begin{vmatrix} pg_{LL} & pg_{LK} \\ pg_{KL} & pg_{KK} \end{vmatrix}$$

and

$$F_{Kp} = \begin{vmatrix} pg_{LL} & -g_L \\ pg_{KL} & -g_K \end{vmatrix}$$

Note that $|F| > 0$ due to the profit maximization. Hence $sign\frac{dK}{dp} = sign|F_{Kp}|$.

$$|F_{Kp}| = -p\overbrace{g_{LL}}^{(-)}g_K + p\overbrace{g_{KL}}^{(+)}\overbrace{g_L}^{(+)} > 0 \tag{5}$$

Thus, we obtain that $\frac{dK}{dp} > 0$ for PDE.

Consider next a MNE that maximizes the following profit function.

$$\pi_{MNE} = pf(L,\tilde{L},K,\tilde{K}) - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} \tag{6}$$

$$= pL^{\alpha_1}\tilde{L}^{\alpha_2}K^{\beta_1}\tilde{K}^{\beta_2} - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} \tag{7}$$

The first order conditions for profit maximization are

$$\begin{aligned} \pi_L &= pf\frac{\alpha_1}{L} - w = 0 && (8)\\ \pi_{\tilde{L}} &= pf\frac{\alpha_2}{\tilde{L}} - \tilde{w} = 0 && (9)\\ pi_K &= pf\frac{\beta_1}{K} - r = 0 && (10)\\ \pi_{\tilde{K}} &= pf\frac{\beta_2}{\tilde{K}} - \tilde{r} = 0 && (11) \end{aligned}$$

To see how MNE reacts to changes in $\tilde{w}$ we examine

$$\frac{dK}{d\tilde{w}} = \frac{|F_{K\tilde{w}|}}{|F|} \quad \text{and} \quad \frac{d\tilde{K}}{d\tilde{w}} = \frac{|F_{\tilde{K}\tilde{w}|}}{|F|} \tag{12}$$

Note that

$$F = \begin{vmatrix} pf\frac{\alpha_1(\alpha_1-1))}{L^2} & pf\frac{\alpha_1}{L}\frac{\alpha_2}{\tilde{L}} & pf\frac{\alpha_1}{L}\frac{\beta_1}{K} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\alpha_2}{\tilde{L}}\frac{\alpha_1}{L} & pf\frac{\alpha_2(\alpha_2-1)}{\tilde{L}^2} & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_1}{K} & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_1}{K}\frac{\alpha_1}{L} & pf\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}} & pf\frac{\beta_1(\beta_1-1)}{K^2} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_2)}{\tilde{K}}\frac{\alpha_1}{L} & pf\frac{\beta_2}{\tilde{K}}\frac{\alpha_2}{\tilde{L}} & pf\frac{\beta_2}{\tilde{K}}\frac{\beta_1}{K} & pf\frac{\beta_2(\beta_2-1)}{\tilde{K}^2} \end{vmatrix} \tag{13}$$

and that $|F| > 0$ due to profit maximization.

Now we determine MNEs reaction to a change in output prices.

$$\frac{dK}{dp} = \frac{F_{Kp}}{F} \tag{14}$$

Note that $sign\frac{|F_{Kp}|}{|F|} = sign|F_{Kp}|$.

Note further that

$$F_{Kp} = \begin{vmatrix} pf\frac{\alpha_1(\alpha_1-1))}{L^2} & pf\frac{\alpha_1}{L}\frac{\alpha_2}{\tilde{L}} & -f\frac{\alpha_1}{L} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\alpha_2}{\tilde{L}}\frac{\alpha_1}{L} & pf\frac{\alpha_2(\alpha_2-1)}{\tilde{L}^2}\frac{\beta_1}{K} & -f\frac{\alpha_2}{\tilde{L}} & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_1}{K}\frac{\alpha_1}{L} & pf\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}} & -f\frac{\beta_1}{K} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_2)}{\tilde{K}}\frac{\alpha_1}{L} & pf\frac{\beta_2}{\tilde{K}}\frac{\alpha_2}{\tilde{L}} & -f\frac{\beta_2}{\tilde{K}} & pf\frac{\beta_2(\beta_2-1)}{\tilde{K}^2} \end{vmatrix} \tag{15}$$

It is easy to show that

$$|F_{Kp}| = p^3 f^4 \frac{\alpha_1}{L^2}\frac{\beta_1}{K}\frac{\beta_2}{\tilde{K}^2}\frac{\alpha_2}{\tilde{L}^2} > 0 \tag{16}$$

The same argument can be made to show that FHE increases its factor demand for domestic capital as a reaction to a price increase. *Q.E.D.*

Proof of Lemma 2

To determine the impact of a decrease in domestic capital price r on PDEs factor demand we need to determine

$$\frac{dK}{dr} = \frac{|F_{Kr}|}{|F|} \quad fracdLdr = \frac{|F_{Lr}|}{|F|} \tag{17}$$

Note that

$$F_{Kr} = \begin{vmatrix} pf\frac{\alpha_1(\alpha_1-1))}{L^2} & pf\frac{\alpha_1}{L}\frac{\alpha_2}{\tilde{L}} & 0 & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\alpha_2}{\tilde{L}}\frac{\alpha_1}{L} & pf\frac{\alpha_2(\alpha_2-1)}{\tilde{L}^2}\frac{\beta_1}{K} & 0 & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_1}{K}\frac{\alpha_1}{L} & pf\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}} & 1 & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_2)}{\tilde{K}}\frac{\alpha_1}{L} & pf\frac{\beta_2}{\tilde{K}}\frac{\alpha_2}{\tilde{L}} & 0 & pf\frac{\beta_2(\beta_2-1)}{\tilde{K}^2} \end{vmatrix} \tag{18}$$

Note that $sign\frac{|F_{Kr}|}{|F|} = sign|F_{Kr}|$.

It is easy to show that

$$|F_{Kr}| < 0 \tag{19}$$

Similarly we get

$$F_{Lr} = \begin{vmatrix} 0 & pf\frac{\alpha_1}{L}\frac{\alpha_2}{\tilde{L}} & pf\frac{\alpha_1}{L}\frac{\beta_1}{K} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ 0 & pf\frac{\alpha_2(\alpha_2-1)}{\tilde{L}^2} & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_1}{K} & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}} \\ 1 & pf\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}} & pf\frac{\beta_1(\beta_1-1)}{K^2} & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ 0 & pf\frac{\beta_2}{\tilde{K}}\frac{\alpha_2}{\tilde{L}} & pf\frac{\beta_2}{\tilde{K}}\frac{\beta_1}{K} & pf\frac{\beta_2(\beta_2-1)}{\tilde{K}^2} \end{vmatrix} \tag{20}$$

and

$$|F_{Lr}| < 0 \tag{21}$$

The same analysis applies to PDEs and FHEs. *Q.E.D.*

Proof of Lemma 3

Consider first MNE.

Note first that

$$sign\frac{dK}{d\tilde{w}} = sign\frac{|F_{K\tilde{w}}|}{|F|} = sign|F_{K\tilde{w}}| \tag{22}$$

Furthermore, note that

$$F_{K\tilde{w}} = \begin{vmatrix} pf\frac{\alpha_1(\alpha_1-1))}{L^2} & pf\frac{\alpha_1}{L}\frac{\alpha_2}{\tilde{L}} & 0 & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\alpha_2}{\tilde{L}}\frac{\alpha_1}{L} & pf\frac{\alpha_2(\alpha_2-1)}{\tilde{L}^2}\frac{\beta_1}{K} & 1 & pf\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_1}{K}\frac{\alpha_1}{L} & pf\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}} & 0 & pf\frac{\alpha_1}{L}\frac{\beta_2}{\tilde{K}} \\ pf\frac{\beta_2)}{\tilde{K}}\frac{\alpha_1}{L} & pf\frac{\beta_2}{\tilde{K}}\frac{\alpha_2}{\tilde{L}} & 0 & pf\frac{\beta_2(\beta_2-1)}{\tilde{K}^2} \end{vmatrix} \tag{23}$$

It is easy to show that

$$|F_{K\tilde{w}}| = -p^3f^3\frac{\beta_1}{K}\frac{\alpha_2}{\tilde{L}}\frac{\beta_2}{\tilde{K}^2}\frac{\alpha_1}{L^2} < 0 \tag{24}$$

Similarly we could derive the same result for FHEs.

Note that there is no direct impact a change in $\tilde{w}$ would have on PDEs domestic factor demand. However, there is an indirect effect due to the price effect.

To see this recall that the market clearing condition is

$$D(p) = qf(p) + (1-q)g(p) \tag{25}$$

assuming that only MNEs and PDEs produce for the local market and that their total number adds up to one.

Note that

$$\frac{dp}{d\tilde{w}} = -\frac{-q\overbrace{\frac{\partial f}{\partial \tilde{w}}}^{(-)} - (1-q)\overbrace{\frac{\partial g}{\partial \tilde{w}}}^{=0}}{\underbrace{D'(p)}_{(-)} - q\underbrace{\frac{\partial f}{\partial p}}_{(+)} - (1-q)\underbrace{\frac{\partial g}{\partial p}}_{(+)}} > 0 \tag{26}$$

Thus, the price decrease resulting from a decrease in $\tilde{w}$ will lower PDEs input demand for K, as we have seen in Lemma 1. *Q.E.D.*

Proof of Result 1

In order to derive the total impact a change in $\tilde{w}$ has on domestic capital demand we need to determine

$$\frac{dK_{total}}{d\tilde{w}} = q\frac{dK_{MNE}}{d\tilde{\tilde{w}}} + (1-q)\frac{dK_{PDE}}{d\tilde{w}} \tag{27}$$

$$= q\underbrace{\frac{dK_{MNE}}{d\tilde{\tilde{w}}}}_{(-)} + \left[q\underbrace{\frac{\partial K_{MNE}}{\partial p}}_{(+)} + (1-q)\underbrace{\frac{\partial K_{PDE}}{\partial p}}_{(+)}\right]\underbrace{\frac{dp}{d\tilde{w}}}_{(+)} > or < 0 \tag{28}$$

The sign depends on the relative size of these effects. The larger q, the more likely it is to be negative, i.e. the more likely it is that a decrease in $\tilde{w}$ increases domestic capital demand. Similarly, the smaller the price effect, the more likely it is that the sign is negative, i.e. the more likely it is for a foreign wage decrease to have a positive impact on domestic capital demand. *Q.E.D.*