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An Industry-Level View

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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. We argue that the aggregated home country implications of foreign direct investment (FDI) cannot be gauged using firm-level data. Aggregated data, in turn, miss channels through which domestic and foreign activities interact. Instead, industry-level data provide useful information on the link between domestic and foreign investment. We theoretically show that the effects of FDI on the domestic capital stock depend on the structure of industries and the relative importance of domestic and multinational firms. Our model allows distinguishing intra-sector competition from inter-sector linkage effects. We test the model using data on German FDI. Using panel cointegration methods, we find evidence for a positive long-run impact of FDI on the domestic capital stock and on the stock of inward FDI. Effects of FDI on the domestic capital stock are driven mainly by intra-sector effects. For inward FDI, inter-sector linkages matter as well.

Key words: foreign direct investment, domestic capital stock

JEL-classification: F21, F23, E22

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1 Motivation

Multinational activity has increased significantly in recent years. German multinationals are no exception in this regard. Overall, German firms account for about 10% of world outward FDI (Unctad 2006), and these investments have grown quite dynamically. Between 1989 and 2004, the stock of German outward foreign direct investment (FDI)[1] has increased from 2 to 8% of the total domestic capital stock of German firms (Figure 1). German firms hold about twice as much capital abroad as 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. Employment in affiliates of foreign firms in Germany has increased less dynamically from about 1 to 1.5 million workers.

The labor market implications of increased FDI have received much attention in the political arena, 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. Low-skilled labor in Germany might be particularly affected.

As regards the long-run implications of FDI, the impact on the domestic capital stock is even more important. Yet, there is relatively little empirical evidence on the link between the domestic capital stock and FDI.[2] At first sight, aggregated data suggest that increased FDI has not had a significantly negative impact on the domestic capital stock. Over the past decade, the aggregated capital stock has instead remained almost unchanged.

Still, developments of the aggregated capital stock might cloud important differences in adjustment across industries. In this paper, we thus use data at a semi-aggregated level that allow considering channels of interaction between domestic and foreign investment. We contribute to the literature in three ways. First, we use a theoretical model that nests

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1 Unless indicated otherwise, we use FDI to denote the *stock* of capital invested abroad.

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

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 effects of FDI on the domestic capital stock. Second, we break up domestic capital into the investment of domestic and of foreign firms (inward FDI). Third, we estimate the links between domestic and foreign investment activities using data that are aggregated at the industry-level. Our data allow estimating the impact of input- and output market linkages on the relationship between domestic capital and FDI. We also distinguish intra-sector competition from inter-sector linkage effects.

We are not the first to analyze the links between FDI and domestic capital. There are rather two strands in the existing empirical literature addressing this link. A first strand of literature uses aggregated data. Feldstein (1995) finds a negative correlation between FDI and domestic investment in US data. He regresses domestic investment on domestic savings and on FDI, accounting for the endogeneity of FDI using instrumental variable techniques. 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 from OECD-countries for the 1980s and 1990s and, again, find a negative relationship in aggregated data. For a time series of aggregated investment stocks of US multinational firms, in contrast, Desai, Foley, and Hines (2005a) find a positive association between domestic and foreign investment. Faeth (2006) also finds a positive relation using Australian balance of payments data. Recent studies also use German data. Using German balance of payments data, Lipponer (2006b) finds no evidence for a negative impact of FDI on domestic investment. Herzer and Schrooten (2007) analyze the cointegration relationship between domestic capital formation and FDI outflows. They find a positive relationship for the US and a negative relationship for Germany. None of these studies allows studying the links between FDI and domestic capital at an industry-level.

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 to link changes in different types of domestic activities of US multinationals to changes in the foreign activities of these firms. They find a positive impact of FDI: firms that invest abroad also tend to invest more in the home economy.

So, at least for the US, the link between domestic investment and FDI partly differs in the aggregated and in the firm-level data. There are several possible reasons for this observation. First, across different firms that invest abroad, the correlation between domestic and foreign investment need not be the same. Aggregation across firms might thus 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 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 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.[3] 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: FDI) to the outcomes of their 'neighbors' in a comparison group. By definition, such firm-level estimation procedures ignore the impact that FDI of some firms can have on other, *non-comparable* firms.

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[3] See Becker and Muendler (2006) or Kleinert and Toubal (2006) for evidence using German data and testing the labor market implications of FDI.

We follow an intermediate route by using semi-aggregated data at the industry-level. We explicitly model the impact of FDI on other, non-comparable firms in the same sector, on suppliers, and on customers of the firm under consideration. Hence, our model allows distinguishing intra-sector competition from inter-sector spill-over effects of FDI.

To the best of our knowledge, there are hardly any empirical papers studying the effects of FDI on domestic investment at the industry-level empirically. An exception is work by Hejazi and Pauly (2002, 2003) for Canada. They find no statistically significant link between outward FDI and domestic investment across all industries while inward FDI supplements domestic capital formation. However, their study does show a substantial degree of heterogeneity when gross fixed capital formation is broken down in its components, by industry, and by partner country.

Also, theoretical work on the link between FDI and the domestic capital stock is scarce. A few previous papers have also modeled the link between FDI and domestic capital theoretically. Desai, Foley, and Hines (2005b) 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 on 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 via linkages between firms in different industries. To analyze this relationship, we use a production function that captures the complementarity between domestic and foreign capital at the firm level. This choice is motivated by the empirical results of Desai, Foley and Hines (2005b).[4] Barba-Navaretti et al. (2004: Chapter 3) likewise have a model with backward and forward linkages between industries. They analyze the effects of FDI on the host economy by distinguishing product market, factor market, and linkage effects. Linkage effects arise through demand and supply linkages between MNEs and local firms. These linkages can generate positive spillovers between multinational and domestic production which can offset or overturn potential negative product or factor market effects. In contrast to our work, the focus of Barba-Navaretti et

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

al. (2004) is on the host country effects of horizontal FDI, and they do not consider the impact of FDI on the capital stock.

In Part 2, we present a theoretical model which provides the intuition for the linkages between the domestic and the foreign capital stock. The model distinguishes the effects of FDI in the same sector from FDI in input and output industries, and we model intra-sector competition as well as inter-sector linkage effects. We also analyze effects of FDI on domestic and multinational firms. In Part 3, we describe our data. In Part 4, we present the empirical analysis. We distinguish long-run and short-run effects of FDI, and we use detailed industry-level information to separate effects of FDI in different industries. Using panel cointegration techniques, we find evidence for a positive impact of outward FDI in the same sector on the domestic capital stock and on the stock of inward FDI. To some extent, this effect includes effects of input- and output-sector linkages as, on average, about 30% of inputs and outputs are traded *within* industries. Apart from that, we find no evidence of significant inter-industry linkage effects for domestic firms. Inward FDI, in contrast, is positively affected by FDI of input and output sectors. Our results also suggest that the long-run effects of FDI on the domestic capital stock should be studied as the short-run dynamics are rather unstable.

2 Theoretical Model

2.1 General Set-Up

In this section, we develop a theoretical framework to investigate how foreign investment affects the domestic capital stock at the industry-level. For this purpose, we distinguish foreign direct investment in three different industries: FDI that is carried out by firms in the industry under consideration, called industry *Y*, FDI that is done by firms in industries that deliver inputs to industry *Y*, called industry *I*, and FDI that is carried out by firms in industries that produce output with inputs received from industry *Y*, called industry *O*. Hence, our model allows analyzing home country effects of FDI through backward and forward linkages.

To assess how FDI in these three different industries affects the domestic capital stock, we further need to distinguish three types of firms active in industry Y 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 on the home market and abroad. Foreign held enterprises are owned by foreigners and operate both on the home market and abroad. In our empirical analysis, we will be able to distinguish the domestic demand for capital of domestic companies (i.e. MNEs *plus* PDEs), and of foreign held companies (FHEs).

We describe firms by 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. (See, e.g., Barba-Navaretti et al. (2004: Chapter 5).) Our reduced form of describing a firm allows focusing on the profitability effects arising from FDI.

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 $f(L_f, \tilde{L}_f, K_f, \tilde{K}_f)$ where $K_f(\tilde{K}_f)$ is capital invested domestically (abroad) and $L_f(\tilde{L}_f)$ is any other input employed domestically (abroad). L could be any other non-traded factor input which, for convenience, we call 'labor'. A $\sim$ denotes foreign variables. This production function captures the idea that the MNE takes advantage of the possibility to locate part of its production abroad. Domestic firms are characterized by a production function $g(L_g, K_g)$. Finally, foreign held firms produce with a production function $h(L_h, \tilde{L}_h, K_h, \tilde{K}_h)$. 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.

We use the following specifications of production functions for the domestic market:

$$f(L_f, \tilde{L}_f, K_f, \tilde{K}_f) = L_f^{\alpha_f} \tilde{L}_f^{\tilde{\alpha}_f} K_f^{\beta_f} \tilde{K}_f^{\tilde{\beta}_f}$$

$$g(L_g, K_g) = L_g^{\alpha_g} K_g^{\beta_g} \qquad (1)$$

$$h(L_h, \tilde{L}_h, K_h, \tilde{K}_h) = L_h^{\alpha_h} \tilde{L}_h^{\tilde{\alpha}_h} K_h^{\beta_h} \tilde{K}_h^{\tilde{\beta}_h}$$

To rule out economies of scale, we restrict the sum of the factor shares in the production function to $\sum \alpha + \sum \beta \leq 1$.[5] 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. For notational convenience, we assume that all firms produce homogenous goods. Thus, the domestic product market can be described by a demand function $p(X)$, where X is total output produced by MNEs, FHEs and PDEs. The market price p adjusts such that the product market is cleared. All firms take the market price as given, i.e. all firms behave as price takers. A straightforward extension of our analysis would allow firms to produce heterogeneous goods. In this case, demand would not be characterized by a single market price, but rather by product specific prices, with negative cross price elasticities and hence similar competition effects as described below.

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

$$\begin{aligned}
\pi_{MNE} &= p(X)\, f(L_f, \tilde{L}_f, K_f, \tilde{K}_f) - wL_f - \tilde{w}\tilde{L}_f - rK_f - \tilde{r}\tilde{K}_f \\
\pi_{FHE} &= p(X)\, h(L_h, \tilde{L}_h, K_h, \tilde{K}_h) - wL_h - \tilde{w}\tilde{L}_h - rK_h - \tilde{r}\tilde{K}_h \qquad (2) \\
\pi_{PDE} &= p(X)\, g(L_g, K_g) - wL_g - rK_g \quad .
\end{aligned}$$

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[5] This specification requires that multinational firms have non-zero inputs of foreign capital and labor. To rule out the possibility that a termination of foreign activities would jeopardize domestic production, we could use $L^{\alpha}(1+\tilde{L})^{\tilde{\alpha}} K^{\beta}(1+\tilde{K})^{\tilde{\beta}}$ as an alternative specification. This would leave our main results unaffected while making the exposition more cumbersome.

We start by investigating how factor demand reacts to changes in input and output prices. We then address 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 *w*. 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

Table 1: Industry-Level Effects of FDI

FDI originating from / FDI motivated by	Industry *Y*	Industry *I*	Industry *O*
Lower foreign input prices (vertical FDI)	**Case 1** MNE and FHE experience reduction in $\tilde{w}$	**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*

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 of the newly emerging markets or by a reduction in transaction cost that affects the net revenue from foreign sales.

The effects of FDI on the home economy depend on the motive driving the foreign investment, and input and output sectors may be affected differently. Recall that we study FDI in three different industries. In each industry, FDI may be motivated by a change in the input price or a change in the output price in the foreign market. Thus, there are six potential scenarios to be considered. Table 1 summarizes the implications of these six different scenarios from the point of view of firms in industry *Y*.

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 a MNE to increase its employment of foreign labor and hence, due to the positive cross

derivatives of the production function, also the foreign and the domestic capital stock. This leads to an increase in domestic production and hence a lower market price *p*. From Lemma 1, however, we know that a decrease in *p* reduces factor demand. This has a negative effect on PDEs, which use less domestic labor and less domestic capital. The overall effect is summarized in the following result.

Result 1

Consider FDI from sector *Y* that is motivated by a decrease in the foreign price for labor $\tilde{w}$. This has two effects:

- The domestic capital stock K_f by MNEs increases and
- the domestic capital stock K_g 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*, and
- the less price elastic product demand.

Proof: See Appendix.

Thus, the overall effect depends on the strength of the negative price effect and on the relative market shares of MNEs and PDEs.

Total production for the home market cannot decrease. If this were the case, the 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.

We have ignored FHEs so far. How would they be affected in this case of vertical investment? As multinationals, they should benefit from improved production opportunities like MNEs, and they should react like MNEs with an increase in production and in domestic input demand.

Case 2: Effects of horizontal FDI in the same industry

We interpret a horizontal foreign investment as being driven by an increase in the foreign output price, for example due to an increase in foreign market size. How would this affect domestic production and factor demand? One possibility could be that the foreign output price increase reflects a global economic upswing, leading also to an increase in the domestic output price. In this case, we can capture the effect of a horizontal investment by an increase in domestic output price p. The more correlated changes in demand abroad and at home are, and thus the more symmetric changes in prices, the more likely is a positive impact on the domestic market.

If, however, the foreign output price increase is purely local, we would still expect domestic production to be affected due to positive externalities of foreign on domestic production.[6] In this case, the effects would be analogous to those resulting from a reduction in foreign input prices as analyzed in Case 1. Using Lemma 1 we can summarize the results as follows:

Result 2

Consider FDI from sector Y that is motivated by an increase in the foreign market price. Suppose the domestic market price increases as well. Then the domestic capital stock by MNEs, PDEs and FHEs increases. The smaller the domestic price increase, the less likely is an increase of the domestic capital stock.

Case 3: Effects of FDI in input industries

Next, we consider foreign investment that is made by firms in industry I delivering inputs to industry Y. If this investment is motivated by output price changes (Case 3b), then there is no reason to expect an impact on industry Y. If, however, the investment is motivated by input price changes (Case 3a), then all firms in industry Y experience a reduction in their input prices. In this sense, FDI in input industries has effects similar to those resulting from outsourcing of stages of production in the same industry. We capture

[6] Foreign production is not modelled explicitly but it can be thought of as being symmetric to domestic production insofar as foreign capita and domestic capital are complements.

this effect by a reduction in the price for domestic input *L*, *w*. As shown in Lemma 2 we get the following result:

Result 3

Consider FDI in input industry *I* that is motivated by lower input prices abroad. This leads to a reduction in the domestic input price *w* for firms in industry *Y* 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 industry *O* that is buying inputs from industry *Y*. If the investment is driven by an input price reduction abroad (Case 4a) and if this input is a substitute for the input produced in industry *Y*, then a reduction in output prices for the industry under consideration will result. 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 output prices would increase. 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 *Y*, firms in industry *Y* 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 *Y* 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 effects of FDI on the domestic capital stock 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 input industries tends to have a positive impact on the domestic capital stock whereas FDI in output industries can have a positive or a negative effect.

3 The Data

To test the above model, we need a dataset which provides industry-level information on the volume of FDI, on the domestic capital stock of domestic and foreign firms, on the number of multinationals and purely domestic firms, on input-output linkages across industries as well as on the employment at the industry-level. Here, we describe the data that we use to test the predictions of this model.[7]

3.1 Data on Foreign Direct Investment

Our industry-level data on inward and outward FDI come from the firm-level database *MiDi* (Micro database Direct Investment, formerly 'International Capital Links') provided by the *Deutsche Bundesbank*. (For details on this database see Lipponer (2006a).) The *MiDi*-database is a full sample survey of German firms' foreign affiliates and of foreign firms' affiliates in Germany, and it contains comprehensive information on affiliates' balance sheets.

We aggregate the data using 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. 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,

[7] Details on the data specification and sources are given in the appendix.

holding companies, which account for about 46% of total outward FDI, are particularly important. The final dataset includes 13 manufacturing and 9 services industries.

Investments with a volume below a certain threshold need not be reported, and the reporting limits have changed over time. To avoid changes in our explanatory variables resulting from changes in reporting limits, we drop all observations that are not covered by the most restrictive reporting requirements. Overall, we delete about 60% of the number of firm-level observations (see Table 2). The loss of observations is less severe for the total volume of activities as 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, mean affiliate sales and employment increase by about 40% but the mean volume of FDI is almost unchanged.

We create a dataset that contains two main measures of multinational activity: the volume of sales of foreign affiliates of German firms and the number of foreign affiliates by industry. The same type of information is obtained for affiliates of foreign held 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. In order to capture the motives for FDI indirectly, we split the data in two ways. First, we split the data into multinational activity with high-income countries – for which horizontal FDI is likely to dominate – and with low-income countries and accession states – for which vertical FDI is likely to prevail. 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 finer 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

The *MiDi*-database does not provide information on a number of control variables of interest. Most importantly, it contains very little information on the parent firms. We therefore obtain industry-level information from the OECD's STAN database and from the German Statistical Office. During our sample period (1991-2004), the Federal Statistical Office changed industry classifications for the national accounts twice. The data that we use have been adjusted for these changes. For employment and hourly wages, we use data from national accounts, which are compatible with International Labour Organization (ILO) standards. We additionally include a dummy variable for the post-unification period which might also pick up some of the effects of the reclassification of industries described above.

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 purely domestic and domestic multinational firms. We therefore decompose the capital stock in Germany 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, $K^D = K - K^{FHE}$. We measure inward and outward foreign direct investment using the *MiDi*-database and aggregating the data by industry and year. 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 Linkages

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 obtained from the German Statistical Office, we construct a year-specific 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*.

More specifically, we include not only FDI in industry *i* but also FDI of input and output sectors denoting FDI_{it}^{I} as the weighted amount of FDI that industry *i* „receives'' via inputs from other industries in year *t* and FDI_{it}^{O} as the amount of FDI that is attributable to industry *i* via its output-links to other industries.

We define $FDI_{it}^{I} = \sum_k w_{kit} FDI_{kt}$ as the weighted sum of FDI from all industries *k* that deliver inputs to industry *i*. We calculate the weights as the proportion of inputs that industry *i* receives from industry *k* relative to its total inputs $w_{kit} = inp_{kit} / \sum_k inp_{kit} = inp_{kit} / inp_{it}$ with $\sum_k w_{kit} = 1 = w_{it}$ and *inp* = value added in input sectors.

We define $FDI_{it}^{O} = \sum_j w_{jit} FDI_{jt}$ as the weighted sum of FDI from industries *j* that industry *i* delivers outputs to, where $w_{jit} = outp_{jit} / \sum_j outp_{jit} = outp_{jit} / outp_{it}$, with $\sum_j w_{jit} = 1 = w_{it}$ and *outp* = value added in output sectors.

We have information on time-varying input-output sector shares from 1991 only through the year 2000. Hence, in order to avoid loosing observations for recent years, we use the weights for the year 2000 as a proxy for the weights in the years 2001-2003. The weights of inputs (outputs) received from (delivered to) the own sector are set equal to zero. Otherwise, we would double-count own sector FDI. On average, these intra-sector input-output linkages account for about 30% of industries' inputs and outputs. Hence, for a large share of the total inputs and outputs, we cannot separate the competition from the linkage effects identified in the theoretical model. Finding an effect of same-sector FDI

could thus be due to a positive direct impact of FDI on the domestic capital stock or an indirect effect working through inter-firm linkages.

Recall from our theoretical considerations above that the impact of FDI on the domestic capital stock in industry *i* depends on who is investing abroad and for what reason. 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.

4 Empirical Model and Regression Results

The theoretical model has shown that the impact of FDI on the domestic capital stock is not clear a priori. The impact rather 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 and to test the importance of input-output sector linkages.

4.1 Empirical Model

The baseline empirical model that we estimate gives the response of the domestic capital stock owned by residents K_{it}^{D} to the price of labor and the levels of employment, output, and FDI:

$$K_{it}^{D} = \alpha_o + \beta_1 (w/p)_{it} + \beta_2 L_{it} + \beta_3 Y_{it} + \beta_4 FDI_{it} + \delta' \mathbf{d}_i + \varepsilon_{it}, \qquad (3)$$

where FDI_{it} is a vector including inward and outward *FDI*, $(w/p)_{it}$ = real hourly wages, L_{it} = employment, Y_{it} = output. ε_{it} is an error term, *i=1, ... , 21* denotes the industry, and *t* = 1991, ... , 2004 is time. Multinational activity is captured through the volume of inward and outward FDI and the number of multinationals in each industry. In contrast to Desai et al. (2005b), who do not control for the level of output, this specification estimates the *ceteris paribus* effects of FDI on the domestic capital stock *at a given scale of activities*. (See Hanson et al. (2003) for a similar specification using the demand for labor as the

dependent variable.) All variables are in logs, thus the coefficients can be interpreted as elasticities.

Ideally, we would also include a proxy for the real interest rate. However, we are unaware of data that measures the interest rate at the industry-level. We include a full set of industry fixed effects (δ') through which we aim to capture differences across industries such as differences in (real) interest rates.

4.2 Long-Run Determinants of the Domestic Capital Stock

We estimate equation (3) using data aggregated across industries and years. In addition, we also estimate the response of the log of the stock of inward FDI to a similar set of explanatory variables: $K_{it}^{FHE} = \alpha_o + \beta_1 (w/p)_{it} + \beta_2 L_{it} + \beta_3 Y_{it} + \beta_4 K_{it}^{D} + \beta_5 FDI_{it}^{outward} + \delta' d_i + \varepsilon_{it}$,

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 $N = 21$ and the time series $T = 13$ (1991-2003). Ignoring non-stationarity of the data may thus lead to spurious regressions, as in time series data.

We run panel unit root tests to check whether our variables might be non-stationary. The results of these tests, which are reported in Table 3, provide evidence for outward FDI to be non-stationary. For some other variables, the results are less clear cut and depend on the specific unit root test chosen. 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 et al. 2005). Using the panel unit root test proposed in Breitung and Das (2005), which accounts for cross-sectional dependence, in fact provides somewhat greater evidence for the presence of a unit root than tests assuming cross-sectional independence. In the following, we therefore proceed under the assumption that our main variables of interest could be non-stationary.

We have two options for dealing with non-stationary data. One option is to first difference all data in logs and to estimate the model in growth rates rather than log-levels. This method has the advantage that the dependent variable is stationary. 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, but it does not give their long-run determinants. The second method is to test for cointegration among the variables of interest and to estimate the long-run cointegration coefficients.

Since our main interest is in the long-run effects of FDI on the domestic capital stock, we test for the presence of a long-run cointegration relationship among our variables of interest by estimating a cointegrated panel model (Breitung 2005). For a VAR(1) model, the cointegrated model has the following Vector Error Correction Model (VECM) representation:

$$\Delta y_{it} = \alpha_i \beta y_{i,t-1} + \varepsilon_{it} \tag{4}$$

with $t = 0,1,\ldots,T$ and $i = 1,\ldots,N$, $E(\varepsilon_{it}) = 0$, $\sigma_{\varepsilon} = E(\varepsilon_{it}\varepsilon'_{it})$. 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) vary for each industry *i*. Since the cointegration estimator requires a balanced panel, we drop all industries which have incomplete time series for the main variables of interest. This leaves us with our sample of $T = 13$ and $N = 21$.

Before looking at the estimated long-run cointegration coefficients, Table 4 provides results of cointegration tests. These results support the presence of cointegration relationships among the variables of interest. Some specifications for the domestic capital stock at the industry-level are exceptions. Yet, these specifications apply tests for panel cointegration which do not allow for cross-section heterogeneity. This is an unrealistic assumption considering the ongoing process of structural change and thus different time trends across industries.

In Tables 5a and 5b, 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. We also present four specifications: the baseline

specifications for the domestic capital stock and the stock of inward FDI (Tables 5a and 5b) as well as the specifications using FDI of input and output sectors as additional explanatory variables (Tables 5c and 5d). To save space, we report these specifications only for the Two-Step estimator.

Baseline Regressions

Table 5a shows that 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. Employment and wages have a positive and significant effect 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).

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 5b). Recall that inward FDI measures domestic investment of foreign-held firms. Thus, we expect inward FDI to react to outward FDI as domestic investment of German multinationals. The larger coefficient confirms our prediction that domestic capital investment of purely domestic firms plus German multinationals should react less positively than domestic investment of foreign-held multinationals (inward FDI).

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. The estimated elasticity is close to one. The link between inward FDI and the domestic capital stock is positive and significant as well.

Inter-Sector Linkage Effects

So far, we have focused on the effects of FDI in the same sector on domestic capital. These include intra-sector competition as well as linkage effects, to the extent that inputs and outputs are traded within sectors. Next, we turn to the results on inter-sector linkages.

Tables 5c and 5d have the results including the FDI of input and output sectors. In addition to inward and outward FDI of the same industry, we add inward and outward FDI of input and output sectors, FDI^{I}_{it} and FDI^{O}_{it}, as described in section 3.4. Generally, our results for the control variables are confirmed. For the domestic capital stock though, we find no consistent effect of inward FDI in input or output sectors or of outward FDI in output sectors. Even if some of these variables are significant, results are not stable across the different types of specifications for the cointegration estimators. The effects of inward FDI in input sectors, for instance, is positive when using the FMOLS estimator (unreported) and insignificant when using the Two-Step estimator. Using the Two-Step estimator, inward FDI of output sectors even has a negative effect on the domestic capital stock, but this finding is not robust across unreported different model specifications. The only inter-industry effect which has a consistent effect across specifications is that of outward FDI in input sectors. This variable has a positive and significant effect at least at the 5% level of significant. This confirms our hypothesis that outward FDI which makes input sectors more competitive has a positive spill-over effect.

For inward FDI, there is greater evidence for positive inter-sector linkages than for the domestic capital stock. All four proxies of inter-industry linkages considered increase inward FDI. Moreover, the estimated elasticities are quite high (around 0.5). Thus, for the investment for foreign held multinationals, the coefficients have the predicted sign and are significant. Outward FDI in input sectors, which can be interpreted as a reduction of output prices, leads to higher investment of foreign multinationals. Similarly, inward FDI in input sectors should lead to lower input prices, which explains the positive impact on domestic investment.

To sum up the evidence on industry-linkages, we find consistent but rather weak effects of inter-industry effects of FDI on domestic investment. Hence, even when inter-industry effects are not taken into account, we can expect not to miss important effects with one

particular industry. Understanding the determinant of inward FDI, in contrast, requires using information about inter-sector linkages. Note, in addition, that our measures of input and output sector FDI capture the FDI of *other* industries only. Since almost a third of inputs and outputs is traded *within* industries, we cannot isolate this effect from the overall competition effects captured by our measures of same-sector FDI.

Effects of industry concentration

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 these results. 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.

Our theoretical model shows that positive effects of outward FDI on the domestic capital stock are more likely the lower the price elasticity of product demand – and thus the lower the degree of competition. We do not have time-varying information on the price elasticity of product demand for different industries at hand. Hence, we proxy the degree of competition by the industry-level Herfindahl index. Information on the Herfindahl index is obtained from the German Antitrust Commission, the *Monopolkommission* (2006), for the year 2003 for 17 sectors under study. We use the Herfindahl to split the sample into sectors with a degree of competition above and below the median. Results for these sample splits are reported in Table 6.[8]

Our expectation is that a higher degree of competition in an industry makes a positive response of the domestic capital stock less likely. We would thus expect a less positive or even negative response of domestic capital (inward FDI) in industries with a Herfindahl below the median, and a more positive response in industries with a Herfindahl above the

[8] Note that the following results are based on fixed effects panel regressions using the first lags of each variable to control for the endogeneity of the regressors and robust standard errors. We do not report panel cointegration test since the number of observations is relatively small for the individual sub-samples.

median. Our main results for domestic capital do not support this (see Table 6a). In both sub-samples, the effect of outward FDI is insignificant. However, in unreported fixed effects regressions the effect of outward FDI is weakly positive in sectors with a low degree of competition and insignificant otherwise.

Effects of the share of multinationals

Our theoretical model also suggests that the number of multinational firms which are active in an industry affect the response of the domestic capital stock to FDI. The higher the share of multinationals, the more likely is a positive response. To test this prediction, we use two time-invariant proxies for the importance of multinational firms in an industry: the number of domestic headquarters of multinational firms and the number of foreign affiliates of domestic firms. Both measures are measured in relation to the total number of firms in an industry. For the domestic capital stock, our results strongly support our theoretical hypothesis. The effect of outward FDI on domestic capital is positive in industries with an above-average share of multinational firms. There is even weak evidence for a negative response of the domestic capital stocks in sectors with a below-average importance of multinational firms.

Interestingly, these patterns in the data are not confirmed for the regressions using inward FDI as the dependent variable (see Table 6b). Here, the link between outward FDI and the domestic capital stock is positive in all sub-samples, and the coefficient estimates are even higher in the industries with a high degree of competition. One reason for these differences in the responses of domestic capital and inward FDI could be that our proxies for the degree of competition and the share of multinationals are related to domestic, not foreign industries. Therefore, results support our approach of treating the response of the domestic capital stock and of inward FDI separately.

4.2.1 Short-Run Dynamics

The analysis so far has focused on the long-run determinants of domestic investment. Earlier studies, in contrast, have focused on the short-run dynamics of the domestic capital stock by using its first difference or gross capital formation as the dependent variable. To check whether the relationships borne out in the long-run also affect the

short-run adjustment responses of the domestic capital stock, we have also estimated equation (3) using first differences of the data.

Table 7 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. Tables 7a and 7b have the results for domestic capital and inward FDI. We present results of fixed effects panel regressions as well as of instrumental variable regressions. 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 variables such as GDP growth are significant determinants 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.). Here, we simply used lagged FDI terms as well as lags of the remaining explanatory variables 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 7a, 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 0.3. The IV estimates yield higher elasticities for employment but lower values for wages. The impact of output growth is insignificant. These results are not affected by adding different measures of FDI as regressors. The FDI measures are (weakly) significant in only one specification, as we find a negative coefficient of the

growth of inward FDI on the domestic capital stock. This effect is insignificant though in the IV-estimates.

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 7b. 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. 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 effect is insignificant though in the IV estimates.

Overall, results using the first difference of the domestic capital stock as the dependent variable provide less stable results on the link between the stock of foreign investment and the domestic capital stock. Moreover, these estimates do not inform us about the underlying long-run relationships in the data.

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 recent papers use firm-level data. The focus of this paper is on the long-run implications of FDI on the domestic capital stock and on the effects of FDI at the industry-level. Our approach also allows distinguishing intra-sector competition from inter-sector linkage effects.

Our theoretical model has shown that the impact of FDI on domestic investment 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 input

industries tends to have a positive impact on the domestic capital stock whereas FDI in output industries can have a positive or 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 the capital stock owned by domestic investors and the stock of inward FDI. For the domestic capital stock, this positive effect tends to be stronger the more multinational firms are active in an industry, as predicted by our model.

Second, we split FDI into proxies for FDI driven by market-access considerations and FDI driven by cost considerations. Generally, we confirm the positive impact of FDI on the domestic capital stock. However, results give no clear-cut implications as to whether this effect is driven by a particular type of FDI.

Third, FDI of other input and output sectors has no significant impact on the domestic capital stock. The stock of inward FDI increases though if other input and output sectors engage in more FDI. When assessing the effects of FDI on the domestic capital stock, intra-sector effects thus dominate. Due to a high share of inputs and outputs that are traded within industries, this may be due to both, competition and linkage effects.

Fourth, understanding the long-run impact of FDI on domestic economic activity requires estimating the long-run (cointegration) parameters. Estimating the model in first differences shows that the short-run link between the domestic capital stock and the stock of FDI is rather weak.

Overall, we show that the activities of multinationals affect the allocation of capital across industries. 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. Yet, at the industry-level, differences are quite distinct. Industries that have invested more abroad have, in the longer run, also increased their domestic capital stock.

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Appendix

Data Definitions and Sources

Foreign Direct Investment

Measures of inward and outward 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 (2006a).

Industry-level data

Unless indicated otherwise, 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/). 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.

- Real gross value added (*Bruttowertschöpfung*) (2000 = 100), Code PRO013
- Gross wages in million € , 1991-2003, Code VST005
- Number of employees in 1000 (headcounts), 1991-2003, Code ERW005
- Exports by manufacturing sector, 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)
- Industry Herfindahl (Monopolkommission 2006) (absolute HHI based on enterprises) (for the year 2003)
- Input-Output coefficients industry by industry and by year, 1991-2000, are from the German Statistical Office (*Volkswirtschaftliche Gesamtrechnungen. Input-Output-Rechnung in jeweiligen Preisen*)
- Share of multinational firms: number of parents of multinational firms and number of foreign affiliates of German multinationals (both calculated based on MiDi) relative to number of firms per industry (obtained from the *Unternehmensregister* of the German Statistical Office) (for the year 2004)

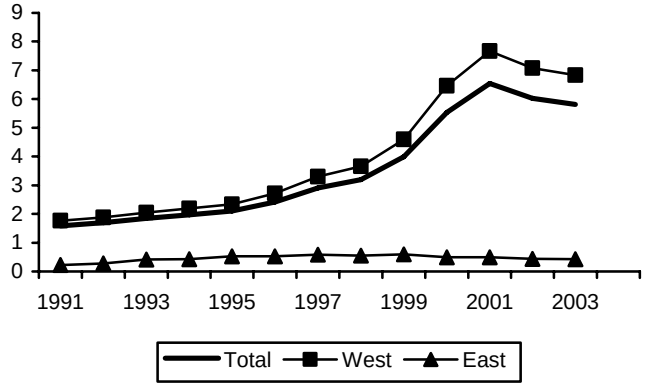
The following data are taken from the Groningen 60-Industry Database (Groningen Growth and Development Centre, 60-Industry Database, October 2005, http://www.ggdc.net/.)

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

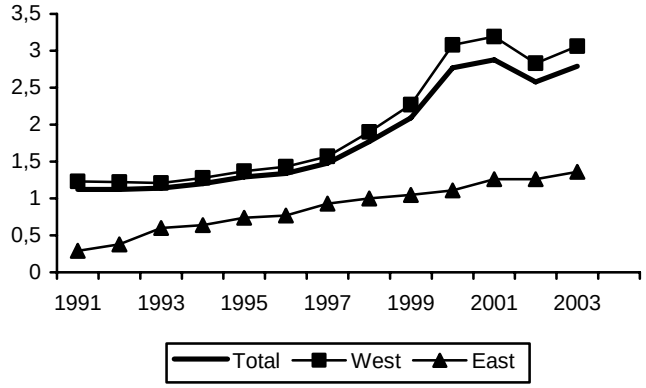
Figure 1: FDI and Foreign Employment in % of Total

The aggregates for West comprise Berlin, East is East Germany without (East-) Berlin.

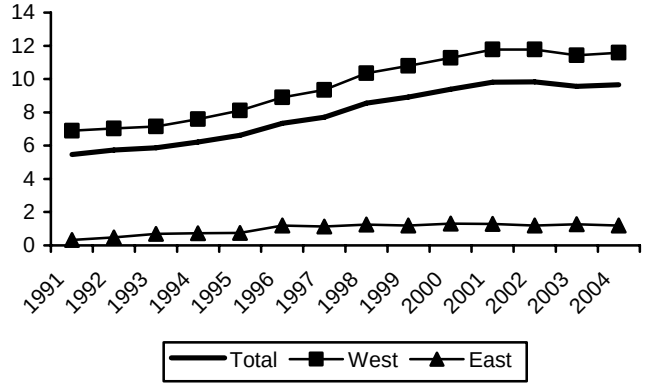
(a) Stock of outward FDI in % of domestic capital stock



(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

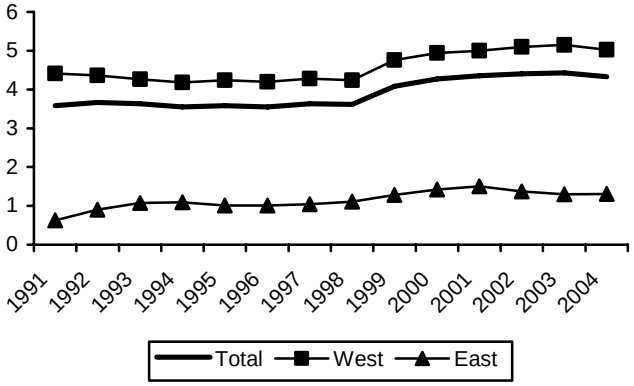


Table 2: Descriptive Statistics Full Versus Reduced Sample

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. *MiDi*-labels are given in parentheses.

(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 3: Panel Unit Root Tests

This Table reports the test statistics of panel unit root tests based on Levin, Lin, and Chu (2002), Im, Pesaran, and Shin (2003), and Breitung and Das (2005). *Number of observations* are for the tests by Levin, Lin, and Chu, and Im, Pesaran, and Shin. 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 10%, 5%, 1%-level.

Variable	Cross sections (number of observations)	Levin, Lin, Chu	Im, Pesaran, Shin	Breitung and Das
Levels				
Domestic capital stock	24 (272)	–16.15***	–8.16***	8.77
Employment	24 (269)	–7.33***	–2.07**	3.47
Real value added	24 (249)	–7.33***	–2.07**	3.47
Inward FDI (volume)	24 (270)	–4.89***	–0.96	–1.32*
Outward FDI (volume)	24 (270)	–1.99**	0.22	0.82
First Differences				
Domestic capital stock	24 (253)	–6.30***	–0.61	–1.20
Employment	24 (252)	–5.12***	0.49	0.48
Real value added	24 (249)	–12.46***	–4.78***	–5.90***
Inward FDI (volume)	24 (252)	–13.36***	–6.19***	–3.81***
Outward FDI (volume)	24 (249)	–10.85***	–3.38***	–4.30***

Table 4: 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 regression equations include employment, wages, output, and inward or outward FDI. *, **, *** = significant at the 10%, 5%, 1%-level.

Dependent variable	Domestic capital stock	Domestic capital stock	Stock of inward FDI
FDI measure	Outward	Inward	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 5: Long-Run Cointegration Coefficients

Tables 5a and 5b present estimates for the long-run cointegration parameters using a fully modified OLS estimator (FMOLS), a dynamic OLS estimator (DOLS), and the Two-Step estimator proposed by Breitung (2005). In Table 5c and 5d, only results using the Two-Step estimator are presented. All estimates presented are for the years 1991-2003 and are based on a sample with $N = 21$ and $T = 13$. *, **, *** = significant at the 10%, 5%, 1%-level.

(a) Domestic Capital Stock (Baseline)

	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)
Number of groups	21	21	21	21	21	21
Observations	252	252	252	252	252	252
R^2	0.62	0.68		0.62	0.67	

(b) Inward FDI (Baseline)

	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)
Number of groups	21	21	21	21	21	21
Observations	252	252	252	252	252	252
R^2	0.53	0.60		0.51	0.66	

(c) Domestic Capital Stock (Including Sector Linkages)

	(1)	(2)	(3)	(4)
Employment	0.45***	0.47***	0.37***	0.40***
	(9.05)	(9.83)	(6.74)	(7.42)
Wages	0.64***	0.75***	0.48***	0.62***
	(12.78)	(15.85)	(7.13)	(9.77)
Output	0.14***	0.13***	0.22***	0.22***
	(3.46)	(3.32)	(5.16)	(5.29)
Inward FDI	0.03***	0.04***		
	(2.89)	(4.17)		
Outward FDI			0.02	0.02**
			(1.62)	(2.08)
Inward FDI input sectors	0.01			
	(0.42)			
Inward FDI output sectors		–0.10***		
		(–4.18)		
Outward FDI input sectors			0.04**	
			(2.69)	
Outward FDI output sectors				–0.01
				(–0.57)
Number of groups	21	21	21	21
Observations	252	252	252	252

(d) Inward FDI (Including Sector Linkages)

	(1)	(2)	(3)	(4)
Employment	–1.05***	–1.12***	–1.18***	–0.75**
	(–2.70)	(–3.59)	(–3.86)	(–2.54)
Wages	0.45	–0.32	–0.44	–0.59
	(–0.02)	(–0.83)	(–1.18)	(–1.56)
Output	1.03***	1.38***	1.32***	1.17***
	(4.91)	(6.35)	(6.07)	(5.46)
Domestic capital stock	0.72***	1.50***	0.74**	1.07***
	(2.63)	(4.31)	(2.15)	(3.27)
Inward FDI input sectors	0.66***			
	(5.47)			
Inward FDI output sectors		0.73***		
		(5.72)		
Outward FDI input sectors			0.48***	
			(6.21)	
Outward FDI output sectors				0.43***
				(7.03)
Number of groups	21	21	21	21
Observations	252	252	252	252

Table 6: Sample Splits by Degree of Competition and MNE Share

In panel (a), the log of the domestic capital stock owned by domestic residents is the dependent variable. In panel (b), the log of inward FDI is the dependent variable. All explanatory variables are in 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. For the IV estimates, the instruments used are the one-period lagged values of log domestic capital stock, log employment, log real value added, and log FDI. MNE share = number of multinational enterprises per industry relative to number of domestic firms. Affiliate share = number of foreign affiliates of German firms per industry relative to number of domestic firms. *** (**, *) = significant at the 1% (5%, 10%)-level.

(a) Domestic capital stock

	Full sample	Herfindahl > median	Herfindahl < median	MNE share > median	MNE share < median	Affiliate share > median	Affiliate share < median
Employment	0.39***	0.38***	0.32**	0.42***	0.42***	0.41***	0.41***
	[4.01]	[3.21]	[2.19]	[3.82]	[4.22]	[3.39]	[4.33]
Wages	0.21	0.2	0.33	-0.01	0.87***	-0.07	0.94***
	[1.54]	[1.12]	[1.34]	[0.11]	[4.00]	[0.56]	[4.14]
Output	0.21***	0.22***	0.05	0.08	-0.03	0.06	-0.01
	[2.80]	[3.31]	[0.16]	[1.21]	[0.18]	[0.77]	[0.05]
Outward FDI	0.03	0.03	0.01	0.06**	-0.02	0.07**	-0.03**
	[1.49]	[1.44]	[0.27]	[2.28]	[1.63]	[2.55]	[2.04]
Unification	-0.07***	-0.06***	-0.08***	-0.07***	-0.05***	-0.08***	-0.04**
	[4.73]	[3.42]	[5.02]	[3.88]	[3.11]	[4.59]	[2.50]
Observations	252	144	108	120	132	127	125
Number of groups	21	12	9	10	11	13	12

(b) Inward FDI

	Full sample	Herfindahl > median	Herfindahl < median	MNE share > median	MNE share < median	Affiliate share > median	Affiliate share < median
Domestic capital stock	0.8	0.68	1.14	-2.18**	2.90*	-1.16	2.88*
	[0.80]	[0.42]	[1.03]	[2.28]	[1.89]	[1.29]	[1.88]
Employment	-1.61**	-1.32	-1.34	0.18	-3.04***	-0.57	-2.89***
	[2.02]	[1.54]	[0.78]	[0.22]	[2.91]	[1.10]	[2.73]
Wages	0.14	0.57	-0.59	0.71	-1.86	0.79	-1.75
	[0.16]	[0.51]	[0.37]	[0.97]	[1.02]	[1.18]	[0.90]
Output	1.12***	1.35***	-0.83	1.42***	1.40**	1.68***	1.29**
	[3.34]	[2.74]	[0.58]	[2.98]	[2.25]	[3.76]	[2.09]
Outward FDI	0.51***	0.37*	1.02***	0.44**	0.69***	0.2	0.69***
	[3.33]	[1.76]	[4.23]	[2.42]	[3.70]	[1.51]	[3.54]
Unification	0.12	0.03	0.30***	-0.05	0.19	0.08	0.2
	[1.34]	[0.25]	[2.59]	[0.52]	[1.47]	[0.77]	[1.44]
Observations	252	144	108	120	132	127	125
Number of groups	21	12	9	10	11	13	12

Table 7: Estimation in First Differences

All variables are entered as first differences of their logs. 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. 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. For the IV estimates, the instruments used are the one-period lagged values of Δ log domestic capital stock, Δ log employment, Δ log real value added, Δ log volume outward FDI, Δ log inward count and Δ log outward count, where count is the number of foreign affiliates in each industry. *** (**, *) = significant at the 1% (5%, 10%)-level.

(a) Change in the domestic capital stock

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel estimates			Panel IV estimates		
Δ Employment	0.17**	0.19**	0.18**	0.67***	0.67***	0.67***
	(2.22)	(2.46)	(2.17)	(4.38)	(3.93)	(3.08)
Δ Output	0.03	0.04	0.03	0.07	0.11	0.07
	(0.73)	(1.01)	(0.76)	(1.23)	(0.85)	(1.23)
Δ Wages	0.33***	0.28***	0.33***	0.17**	0.20*	0.17*
	(4.82)	(4.87)	(4.84)	(2.19)	(1.68)	(1.97)
Δ Inward FDI		-0.03**			0.01	
		(-2.08)			(0.30)	
Δ Outward FDI			0.00			0.00
			(-0.33)			(0.0092)
Unification	0.05***	0.05***	0.05***	0.06***	0.06***	0.06***
	(13.7)	(12.9)	(13.7)	(9.25)	(7.56)	(8.04)
Constant	0.00	0.01**	0.00			
	(0.60)	(2.25)	(0.60)			
Observations	268	268	268	245	245	245
Number of groups	23	23	23	23	23	23
Adjusted R^2	0.51	0.58	0.51			

(b) Change in inward FDI

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel estimates				Panel IV estimates	
Δ Domestic capital stock	-4.41***	-4.37***	-4.48***	.	11.37	13.27
	(-4.40)	(-4.22)	(-4.48)	.	(0.34)	(0.38)
Δ Employment	1.29**	0.83	1.14**	0.06	-8.75	-11.54
	(2.11)	(1.40)	(2.08)	(0.11)	(-0.40)	(-0.50)
Δ Output	0.54***	0.27*	0.2	0.13	-2.23	-2.51
	(3.86)	(1.75)	(1.06)	(0.77)	(-0.67)	(-0.70)
Δ Wages	-0.34	-0.53	-0.91	-1.98	-4	-4.27
	(-0.45)	(-0.66)	(-1.21)	(-1.71)	(-0.56)	(-0.59)
Δ Outward FDI		0.33**		0.34**		0.22
		(2.25)		(2.29)		(0.61)
Unification	0.23**	0.23**	0.25**	0.01	-0.73	-0.86
	(2.49)	(2.32)	(2.66)	(0.15)	(-0.39)	(-0.45)
Constant	0.16***	0.12***	0.13***	0.12***		
	(5.85)	(4.65)	(5.46)	(3.61)		
Observations	268	268	268	268	245	245
Number of groups	23	23	23	23	23	23
Adjusted R^2	0.16	0.24	0.32	0.11		

Mathematical Appendix

In the Appendix we will drop all indices referring to production functions f, g and h for notational convenience.

Proof of Lemma 1

Consider a purely domestic enterprise (PDE) that maximzes the following profit function

$$\pi_{PDE} = pg(L,K) - wL - rK \tag{5}$$

The first order conditions for profit maximization are

$$\pi_L = pg_L - w = 0 \tag{6}$$

$$\pi_K = pg_K - r = 0 \tag{7}$$

To determine how the capital stock of a PDE reacts to changes in p note that

$$\frac{dK}{dp} = \frac{|F_{Kp}|}{|F|} \tag{8}$$

where

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

and

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

To ensure that the solution corresponds to a profit maximum, we need to check that $|F| > 0$. It is straightforward to show that

$$|F| = pg_{LL}pg_{KK} - pg_{LK}pg_{KL} \tag{9}$$

$$= p^2 \frac{1}{L^2}\frac{1}{K^2} g^2[\alpha(\alpha-1)\beta(\beta-1) - \alpha^2\beta^2] > 0 \tag{10}$$

if $\alpha + \beta < 1$, as assumed above.

Since $|F| > 0$, $sign\frac{dK}{dp} = sign|F_{Kp}|$.

Note that

$$|F_{Kp}| = -p\overbrace{g_{LL}}^{(-)}g_K + p\overbrace{g_{KL}}^{(+)}\overbrace{g_L}^{(+)} > 0 \tag{11}$$

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

Consider next a domestic multinational enterprise (MNE) that maximizes the following profit function.

$$\begin{aligned} \pi_{MNE} &= pf(L, \tilde{L}, K, \tilde{K}) - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} && (12)\\ &= pL^{\alpha}\tilde{L}^{\tilde{\alpha}}K^{\beta}\tilde{K}^{\tilde{\beta}} - wL - \tilde{w}\tilde{L} - rK - \tilde{r}\tilde{K} && (13) \end{aligned}$$

The first order conditions for profit maximization are

$$\begin{aligned} \pi_L &= pf\frac{\alpha}{L} - w = 0 && (14)\\ \pi_{\tilde{L}} &= pf\frac{\tilde{\alpha}}{\tilde{L}} - \tilde{w} = 0 && (15)\\ \pi_K &= pf\frac{\beta}{K} - r = 0 && (16)\\ \pi_{\tilde{K}} &= pf\frac{\tilde{\beta}}{\tilde{K}} - \tilde{r} = 0 && (17) \end{aligned}$$

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

$$\frac{dK}{d\tilde{w}} = \frac{|F_{K\tilde{w}}|}{|F|} \quad \text{and} \quad \frac{d\tilde{K}}{d\tilde{w}} = \frac{|F_{\tilde{K}\tilde{w}}|}{|F|} \tag{18}$$

Note that

$$F = \begin{vmatrix} pf\frac{\alpha(\alpha-1)}{L^2} & pf\frac{\alpha}{L}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\alpha}{L}\frac{\beta}{K} & pf\frac{\alpha}{L}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\alpha}{L} & pf\frac{\tilde{\alpha}(\tilde{\alpha}-1)}{\tilde{L}^2} & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\beta}{K} & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\beta}{K}\frac{\alpha}{L} & pf\frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\beta(\beta-1)}{K^2} & pf\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\alpha}{L} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\beta}{K} & pf\frac{\tilde{\beta}(\tilde{\beta}-1)}{\tilde{K}^2} \end{vmatrix} \tag{19}$$

and that $|F| > 0$ due to the assumption that $\sum\alpha + \sum\beta < 1$.

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

$$\frac{dK}{dp} = \frac{|F_{Kp}|}{|F|} \tag{20}$$

Note that $sign\frac{|F_{Kp}|}{|F|} = sign|F_{Kp}|$, as $|F| > 0$.

Note further that

$$|F_{Kp}| = \begin{vmatrix} pf\frac{\alpha(\alpha-1)}{L^2} & pf\frac{\alpha}{L}\frac{\tilde{\alpha}}{\tilde{L}} & -f\frac{\alpha}{L} & pf\frac{\alpha}{L}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\alpha}{L} & pf\frac{\tilde{\alpha}(\tilde{\alpha}-1)}{\tilde{L}^2} & -f\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\beta}{\tilde{K}} \\ pf\frac{\beta}{K}\frac{\alpha}{L} & pf\frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}} & -f\frac{\beta}{K} & pf\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\alpha}{L} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\tilde{\alpha}}{\tilde{L}} & -f\frac{\tilde{\beta}}{\tilde{K}} & pf\frac{\tilde{\beta}(\tilde{\beta}-1)}{\tilde{K}^2} \end{vmatrix} \tag{21}$$

It is straightforward to show that

$$|F_{Kp}| = p^3 f^4 \frac{\alpha}{L^2}\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}^2}\frac{\tilde{\alpha}}{\tilde{L}^2} > 0 \tag{22}$$

An analogous argument can be made to show that an 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 the domestic input price w on PDEs' factor demand, we need to determine

$$\frac{dK}{dw} = \frac{|F_{Kw}|}{|F|} \qquad \frac{dL}{dw} = \frac{|F_{Lw}|}{|F|} \tag{23}$$

Note that

$$F_{Kw} = \begin{vmatrix} pf\frac{\alpha(\alpha-1)}{L^2} & pf\frac{\alpha}{L}\frac{\tilde{\alpha}}{\tilde{L}} & 1 & pf\frac{\alpha}{L}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\alpha}{L} & pf\frac{\tilde{\alpha}(\tilde{\alpha}-1)}{\tilde{L}^2} & 0 & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\beta}{\tilde{K}} \\ pf\frac{\beta}{K}\frac{\alpha}{L} & pf\frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}} & 0 & pf\frac{\beta}{K}\frac{\beta}{\tilde{K}} \\ pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\alpha}{L} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\tilde{\alpha}}{\tilde{L}} & 0 & pf\frac{\tilde{\beta}(\tilde{\beta}-1)}{\tilde{K}^2} \end{vmatrix} \tag{24}$$

Note that $sign\frac{|F_{Kr}|}{|F|} = sign|F_{Kr}|$ as $|F| > 0$.

It is straightforward to show that

$$|F_{Kw}| = -p^3 f^3 \frac{\alpha}{L}\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}^2}\frac{\tilde{\alpha}}{\tilde{L}^2} < 0 \tag{25}$$

Similarly we get

$$F_{Lw} = \begin{vmatrix} 1 & pf\frac{\alpha}{L}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\alpha}{L}\frac{\beta}{K} & pf\frac{\alpha}{L}\frac{\tilde{\beta}}{\tilde{K}} \\ 0 & pf\frac{\tilde{\alpha}(\tilde{\alpha}-1)}{\tilde{L}^2} & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\beta}{K} & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\tilde{\beta}}{\tilde{K}} \\ 0 & pf\frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\beta(\beta-1)}{K^2} & pf\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}} \\ 0 & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\tilde{\alpha}}{\tilde{L}} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\beta}{K} & pf\frac{\tilde{\beta}(\tilde{\beta}-1)}{\tilde{K}^2} \end{vmatrix} \tag{26}$$

and

$$|F_{Lw}| = p^3 f^3 \frac{\tilde{\alpha}\beta\tilde{\beta}}{\tilde{L}^2 K^2 \tilde{K}^2}(\tilde{a} + \beta + \tilde{\beta} - 1) < 0 \tag{27}$$

since by assumption $\sum \alpha + \sum \beta < 1$.

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

Proof of Lemma 3

Consider first an MNE. Note that

$$sign\frac{dK}{d\tilde{w}} = sign\frac{|F_{K\tilde{w}}|}{|F|} = sign|F_{K\tilde{w}}| \tag{28}$$

as $|F| > 0$. Furthermore, note that

$$F_{K\tilde{w}} = \begin{vmatrix} pf\frac{\alpha(\alpha-1)}{L^2} & pf\frac{\alpha}{L}\frac{\tilde{\alpha}}{\tilde{L}} & 0 & pf\frac{\alpha}{L}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\alpha}{L} & pf\frac{\tilde{\alpha}(\tilde{\alpha}-1)}{\tilde{L}^2} & 1 & pf\frac{\tilde{\alpha}}{\tilde{L}}\frac{\beta}{K} \\ pf\frac{\beta}{K}\frac{\alpha}{L} & pf\frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}} & 0 & pf\frac{\beta}{K}\frac{\tilde{\beta}}{\tilde{K}} \\ pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\alpha}{L} & pf\frac{\tilde{\beta}}{\tilde{K}}\frac{\tilde{\alpha}}{\tilde{L}} & 0 & pf\frac{\tilde{\beta}(\tilde{\beta}-1)}{\tilde{K}^2} \end{vmatrix} \tag{29}$$

It is straightforward to show that

$$|F_{K\tilde{w}}| = -p^3 f^3 \frac{\beta}{K}\frac{\tilde{\alpha}}{\tilde{L}}\frac{\tilde{\beta}}{\tilde{K}^2}\frac{\alpha}{L^2} < 0 \tag{30}$$

We can derive analogous results 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

$$D(p) = qf(p) + (1-q)g(p) \tag{31}$$

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

Note that

$$\frac{dp}{d\tilde{w}} = -\frac{-q\overbrace{\frac{\partial f}{\partial \tilde{w}}}^{(-)} - (1-q)\overbrace{\frac{\partial g}{\partial \tilde{w}}}^{=0}}{\underbrace{D'(p)}_{(-)} - q\underbrace{\frac{\partial f}{\partial p}}_{(+)} - (1-q)\underbrace{\frac{\partial g}{\partial p}}_{(+)}} > 0 \tag{32}$$

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

$$\frac{dK_{total}}{d\tilde{w}} = q\frac{dK_{MNE}}{d\tilde{\tilde{w}}} + (1-q)\frac{dK_{PDE}}{d\tilde{w}} \tag{33}$$

$$= \underbrace{q\frac{dK_{MNE}}{d\tilde{\tilde{w}}}}_{(-)} + \left[\underbrace{q\frac{\partial K_{MNE}}{\partial p}}_{(+)} + (1-q)\underbrace{\frac{\partial K_{PDE}}{\partial p}}_{(+)}\right]\underbrace{\frac{dp}{d\tilde{w}}}_{(+)} > or < 0 \tag{34}$$

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.*