Multinational firms and the relationship between domestic and foreign capital expenditures

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Abstract

When a multinational firm increases its foreign capital expenditures, what should we expect for this firm's domestic capital expenditures? We analyze this question in a two–country general equilibrium framework. The most distinguishing features of our model are the following: (*i*) our setup nests the horizontal and the vertical model of the multinational firm, (*ii*) we endogenize the firms' capital expenditures in terms of the Ramsey growth model, (*iii*) we consider how multinational firms influence factor markets and how this feeds back into the firms' capital expenditures. We find the following: the relationship between domestic and foreign capital expenditures is complementary (substitutional) if multinational activity is horizontal (sufficiently vertical). We test our model with a panel of US multinationals and find empirical support.

JEL classification: F23; F21; E22

Keywords: horizontal multinational firms; vertical multinational firms; general equilibrium model; endogenous capital expenditures; neoclassical growth model; panel data analysis.

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1 Introduction

Rising multinational activity in the past two decades has raised several concerns about how a multinational firm's domestic and foreign activities are related. The most common perception is that a multinational firm, which increases investments abroad, necessarily decreases investments at home. Surprisingly though, the empirical evidence on this issue is mixed so far. Feldstein (1995), for example, finds a negative relationship between domestic and foreign capital expenditures of multinational firms of OECD countries.[1] Desai et al. (2009), in contrast, find a positive relationship between these two variables for US multinationals. These conflicting results indicate that neither an optimistic nor a pessimistic view about multinationals' influence on the domestic economy captures the full story.

Intuitively, the relationship between domestic and foreign capital expenditures of multinationals depends on which production activities are kept at home and which are shifted abroad. Horizontal multinationals produce in several countries with identical technologies, while vertical multinationals concentrate labor (capital) intensive production activities in relatively labor (capital) abundant countries. Thus, the aggregate finding of multinationals' foreign capital expenditures being complementary or substitutional to their domestic capital expenditures may be rather distinct for either of the two types of multinationals.

This paper intends to contribute to the debate. We formulate a dynamic two–factor, two–country general equilibrium model in order to analyze the relationship between domestic and foreign capital expenditures of multinational firms. Relative to the previous literature, we explicitly consider how the firms' production technologies at home and abroad influence domestic and foreign capital expenditures. As we derive our results for different technologies of multinational firms, we are able to distinguish between horizontal and vertical multinationals. Furthermore, we endogenize the firms' capital expenditures at home and abroad in terms of the Ramsey growth model. Finally, in our general equilibrium setting multinational firms have a non–negligible impact on the countries' factor markets.

While it is crucial for our results that multinational firms impact factor markets, this reflects the empirical regularity that multinationals are small in number, but large in size. For example, Hanson and Slaughter (2004) report for 1999, that US multinationals and US affiliates of foreign multinationals accounted for 80% of US exports, 42% of US capital expenditures, 24% of US nonbank private sector employment and 32% of US nonbank private sector GDP. UNCTAD (2006) reports for 2001 that multinationals' affiliates accounted for 26% of Austrian exports, 15% of French exports, 61% of Hungarian exports, 20% of Portuguese

[1] Notice that the terms "capital expenditures" and "investments into the capital stock" are used interchangeably in the literature.

exports and 33% of Swedish exports. In some countries, the affiliates of US multinationals alone are already non–marginal in factor markets. Considering aggregate manufacturing employment in 2008, the affiliates of US multinationals accounted for 17% in Canada, 20% in Ireland, 5% in Hungary, 5% in Germany, 11% in the Netherlands, 4% in Spain and 3% in Poland.[2] Finally, National Bureau of Statistics of China (2011) reports that multinationals' affiliates accounted for 55% of Chinese exports in 2010. Thus, given our research question, neglecting multinationals' influence on factor markets would be a limitation of the model.

Crucial for our results is also the way how we model multinational firms. Multinational firms have one production plant at home and one abroad. Each production plant produces an intermediate good and both intermediate goods are assembled to a unique variety of a final good in the country of headquarters.[3] The final good is sold at home and abroad. We define multinationals as *horizontal* (*vertical*) if the domestic and the foreign production plant produce with identical (different) factor intensities. We show the following. If the domestic and the foreign production plant produce with identical factor intensities, and if the domestic and the foreign country are identical in size, net trade of intermediate goods is zero and our setting mimics a setting in which each production plant produces the final good only for the local market. If the domestic and the foreign production plant produce with different factor intensities, the labor (capital) intensive production is located in the relatively labor (capital) abundant country.[4] Thus, our setup nests the horizontal and the vertical model of the multinational firm.

We first derive the steady state general equilibrium of our model. Afterwards, we disturb the steady state by a symmetric shock to country–wide labor productivity and analyze the adjustments of capital expenditures of *existing* multinational firms at home and abroad.[5] Thus, our focus is on the adjustments at the intensive margin of multinational activity. The

[2]These figures are calculated from the labor force statistics of the OECD (www.oecd–ilibrary.org) and the data on the operations by US multinationals by the US Bureau of Economic Analysis (www.bea.gov).

[3]Our results do not depend on where assembly to a unique variety of the final good takes place. The reason is that we abstract from transport costs in our setting, and we explain later why we decided to do so.

[4]An example for our definition of *horizontal* multinationals are firms from the finance sector. Deutsche Bank, for instance, produces most of its services in local hubs (e.g., Frankfurt or London) with local employees and with services from other local hubs for local and foreign customers (Deutsche Bank, 2013). An example for our definition of *vertical* multinationals are car producers such as Toyota. Toyota has production plants for different components of cars in, e.g., China and Japan; still, the final good "car" is produced in Japan and exported to China (Toyota, 2013). Notice though that our definition of vertical multinationals differs from the one in the Knowledge–Capital model by Markusen (2002). Since there are no intermediate goods in the Knowledge–Capital model, vertical multinationals produce the final good directly with labor and capital only in one country and headquarter services in the other country. We separate the production process into two intermediate goods since our focus is on the factor intensities of multinational production in the two countries.

[5]We also analyze the case of (*i*) asymmetric shocks to country–wide labor productivity and (*ii*) symmetric and asymmetric demand shocks. Since the basic workings are the same as with the symmetric shock to country–wide labor productivity, we have shifted the formal analysis of these alternative shocks to an appendix, which is available from the authors upon request.

reasons for focusing on the intensive margin are threefold. First, the previous empirical literature has also concentrated on adjustments at the intensive margin. Therefore, we can directly compare our results with those of earlier studies. Second, due to substantial sunk costs for setting up a production plant abroad, adjustments at the intensive margin are much more frequent and important than adjustments at the extensive margin of multinational activity (e.g., Buch et al., 2010). Third, since the steady state capital stocks are endogenous in our setting, there is no causal relationship between firms' allocation of production activities across countries and countries' steady state relative factor endowments (see Bond et al., 2003). The allocation of production activities across countries impacts steady state relative factor endowments and vice versa. Thus, our model with endogenous capital stocks is not suitable for analyzing a national firm's decision whether or not to become multinational.

If domestic and foreign capital expenditures of multinational firms adjust into identical directions due to the shock, we consider them to be "complements." However, if domestic and foreign capital expenditures by multinationals adjust into opposite directions, we consider them to be "substitutes."

We show the following. If the multinationals' production plants at home and abroad produce with identical factor intensities, i.e. if multinational activity is horizontal, domestic and foreign capital expenditures are complements. This complementary relationship becomes weaker if the production plants at home and abroad produce with increasingly different factor intensities, i.e. if multinational activity becomes increasingly vertical. If multinational activity becomes sufficiently vertical, the relationship between domestic and foreign capital expenditures turns from complementary to substitutional.

The intuition for our results relies on how multinational activity influences relative factor demands in the two countries. In the case of horizontal multinational activity, any adjustment of multinational production leads to an identical reaction of relative factor demands in the two countries. Thus, if multinationals are horizontal, any adjustment of multinational production leads to an identical reaction of relative factor prices and, finally, to an identical reaction of multinationals' capital expenditures in the two countries. However, if multinational firms are vertical, any adjustment of multinational production changes relative factor demands and, thus, relative factor prices at home and abroad into opposite directions. This implies that multinationals' capital expenditures in the two countries adjust into opposite directions as well if multinational firms are vertical.

Afterwards, we test our theoretical model with a panel of US multinational firms. The data is from the US Bureau of Economic Analysis and we consider the most recent years for which data is available (1999–2010). If we do not consider the influence of the firms' technologies and regress domestic sector–level capital expenditures of multinational firms on foreign capital expenditures of the same firms, our panel estimation with year and sector fixed effects leads to insignificant results.

In order to provide a more direct empirical evaluation of our theoretical model, we extend our regression by interaction terms. First, we interact foreign capital expenditures by the ratio of the average wage in the domestic production plant relative to the one in the foreign production plant. Second, we interact foreign capital expenditures with a variable, which captures the difference in the labor intensity between the domestic and the foreign production plant. Thus, both interaction terms capture how the difference in factor intensities between the domestic and the foreign production plant impacts the relationship between domestic and foreign capital expenditures of multinationals.

If we redo our regressions with the interaction terms, our empirical results support our theoretical model. The relationship between domestic and foreign capital expenditures becomes more substitutional, the more vertical multinational firms are, i.e. the more different the factor intensities of domestic and foreign multinational production are.

This paper is organized as follows. In section 2 we relate this paper to the existing literature. In section 3 we describe the theoretical model and in section 4 we derive the steady state of our two–country world with multinational activity. In section 5 we perform a comparative steady state analysis, derive our main results and discuss the mechanisms and underlying assumptions, which drive these results. We provide empirical support for our theoretical model in section 6. Section 7 concludes. Proofs are relegated to the appendix.

2 Previous literature

Our paper extends the large and still growing literature on the effects of multinational activity on the domestic economy.

Early empirical work has been done by Stevens and Lipsey (1992) and Feldstein (1995). These authors emphasize the interaction between domestic and foreign capital expenditures via the financial side, and they provide evidence for the idea that an increase in investments abroad increases a multinational's costs for external capital and, thus, reduces investments at home. While Stevens and Lipsey (1992) find a negative relationship between FDI and domestic capital expenditures with firm level data, Feldstein (1995) finds this negative relationship using country–level data for a sample of OECD countries. More recently, Desai et al. (2005) refine this work by examining domestic and foreign capital expenditures of a sample of US multinationals. Instead of a negative relationship between domestic and foreign capital expenditures, they find a positive and significant link between these two variables.

One possible explanation they put forward is that the US may be different from the average OECD country. Herzer and Schrooten (2008) provide some evidence for this explanation since they find substitutability between FDI and domestic capital expenditures for German data while they find complementarity for US data. A second explanation Desai et al. (2005) put forward relates to the activities of multinational firms which are different from the activities of the average firm. A third explanation relates to the composition of FDI and domestic capital expenditures in both samples in the sense that aggregate FDI data contain financing flows whereas the data for multinationals is restricted to capital expenditures. In a panel of US multinationals, in which they match the domestic and foreign operations of each firm, Desai et al. (2009) find that a 10% increase in foreign capital expenditures increases domestic capital expenditures by approximately 2%. This confirms the aggregate results of Desai et al. (2005). Related is also the empirical work by Harrison and McMillan (2011). These authors analyze how wages at foreign affiliates of US multinationals are linked to employment at the parent company, and how this link depends on the motives for multinational activity.

Theoretical research on the relationship between domestic and foreign investments of multinational firms is scarce and has been started by Stevens and Lipsey (1992). These authors consider imperfect international capital markets which imply that the costs of external capital increase with the debt–to–equity ratio. Thus, if externally financed investments abroad increase, those at home decrease. More recent research has moved away from analyzing aggregate FDI flows, but considers how, for instance, the organization of production influences the relationship between domestic and foreign capital expenditures. Braunerhjelm et al. (2005) distinguish between horizontally and vertically organized industries and show for Swedish multinationals that a substitutional (complementary) relationship exists between domestic and foreign capital expenditures for horizontally (vertically) organized industries. Still, the theoretical discussion in Braunerhjelm et al. (2005) is based on a partial equilibrium reasoning and the firms' capital expenditures are not endogenized. Arndt et al. (2010) consider intra–sectoral competition effects and inter–sectoral linkage effects between multinationals and local firms. Taking German FDI data, they show that outward FDI has a positive effect on the domestic capital stock due to both intra–sectoral and inter–sectoral effects. Dawid et al. (2010) analyze how technological spillovers from vertical multinationals to local competitors influence the firm's trade–off between investments at home and abroad.[6]

Thus, the most distinguishing feature of our setup relative to the previous literature is that we consider a *general* equilibrium setting with *endogenous* capital expenditures by firms.

[6]Papers like, e.g., Markusen and Staehler (2011), Barba Navaretti et al. (2010), Roording and de Vaal (2010) and Bekes et al. (2009) also analyze how multinational activity affects an economy. However, these papers focus on different aspects like competition effects, firm–selection effects or knowledge spillovers due to multinational activity.

In addition, we derive our results for different assumptions about the firms' technologies, i.e. we distinguish between horizontal and vertical multinational firms. In our empirical analysis we also focus on how the firms' technologies influence the relationship between domestic and foreign capital expenditures.

3 Theoretical model

3.1 Overview

We analyze a general equilibrium setting with a home country H, a foreign country F, multinational firms and endogenous capital expenditures in both countries.

The representative household in each country consumes a homogeneous good Z and several varieties of a differentiated good X. The market for good Z is characterized by perfect competition. Households aggregate the varieties of good X according to a CES–function like in Dixit and Stiglitz (1977). Good X is produced by multinational firms and the market for good X is characterized by large–group monopolistic competition (Markusen and Venables, 2000). Countries H and F have access to the same technologies.

Countries H and F are endowed with two factors of production, labor L and capital K, which are mobile between sectors but immobile between countries. Labor and capital are used for the following production activities: first, they are used to produce the homogeneous good Z. Second, they are used to produce intermediate goods v_1 and v_2; both intermediate goods are assembled to a unique variety of the differentiated good X. Finally, capital is used to produce headquarter services and to set up a production plant, which leads to fixed costs.

Multinational firms have two production plants, one in country H and one in country F. We assume that the production plants in country H only produce intermediate good v_1, while the production plants in country F only produce intermediate good v_2. If v_1 and v_2 are produced with identical (different) factor intensities, we define multinational firms as horizontal (vertical). Both horizontal and vertical multinational firms produce with economies of scale due to fixed production costs.

Each country's labor endowment is constant over time. Each country's capital endowment is determined endogenously via the Ramsey growth model. This implies that firms and households choose their capital expenditures in each country according to the scarcity of capital relative to labor in the respective country. We assume that firms and households use the homogeneous good Z for investment purposes.

In order to analyze whether domestic and foreign capital expenditures are complements or substitutes, we will disturb the steady state of the two–country world by a persistent shock to country–wide labor productivity, which occurs symmetrically across countries. If the steady state capital stocks of both countries move into identical (opposite) directions due to the shock, domestic and foreign capital expenditures are complements (substitutes).

Concerning the firms' technologies we make the following assumptions. First, when intermediate goods v_1 and v_2 are produced with different factor intensities, i.e. in the case of vertical multinational activity, v_1 is produced capital intensively, while v_2 is produced labor intensively. Second, the capital (labor) intensive intermediate good v_1 (v_2) is more (less) capital intensive than the homogeneous good Z. Third, we assume that v_1 and v_2 are combined to good X such that good X is at least as capital intensive as good Z. While these assumptions on factor intensities are certainly crucial for our results, they are standard in the previous theoretical work on multinational activity (e.g., Markusen, 2002). In addition, there is ample empirical evidence stating that multinational activity is typically more capital intensive than the average sector, and that vertical multinationals from developed countries typically produce relatively labor intensively in less developed countries (e.g., UNCTAD, 2010, ch. I; Hummels et al., 1998).

In order to focus on the main driving forces behind our results, we make, without loss of generality, three simplifying assumptions. First, we do not explicitly distinguish between firm owners and households, but assume that households own firms. Without this assumption, we would have to specify separate utility functions for households and firm owners. Still, our main conclusions would not change as long as households and firm owners optimize intertemporally and, thus, consider the relative scarcity of capital for their capital expenditures. Second, we assume that trade costs are zero. Third, we assume that all firms in sector X are multinational firms. The last two assumptions are innocent as well since we study in this paper only how domestic and foreign capital expenditures of *existing* multinationals are linked. Since we do not study in this paper a national firm's decision whether to become multinational or not, including trade costs would not add to our analysis, but would complicate the algebra.

Due to zero transport costs and costless assembling of v_1 and v_2 to a unique variety of X, it is immaterial for our results whether multinationals perform the assembling in country H or in country F. Thus, we assume that v_1 and v_2 are assembled to a unique variety of X in the country of headquarters, both for horizontal and vertical multinationals.

We will compare the countries' steady states *before* and *after* the permanent shock, without deriving the adjustment path from the initial to the new steady state. Still, the comparison of both steady states is sufficient in order to determine how capital expenditures in either country react to the permanent shock: if a country's capital stock in the new steady state is larger (smaller) than in the initial steady state, we can conclude that capital expenditures increase (decrease) during the adjustment from the initial to the new steady state.

3.2 Production

Both countries have access to the same production technologies. The homogeneous good Z is produced according to the following Cobb–Douglas production function:[7]

$$Z_i = \frac{K_{Z,i}^{\beta} L_{Z,i}^{1-\beta}}{\beta^{\beta} (1-\beta)^{1-\beta}}, \quad i = H, F, \tag{1}$$

where Z_i stands for the production of good Z in country i and $L_{Z,i}$ and $K_{Z,i}$ for the input of labor and capital in good Z production in country i. The per unit cost function which is dual to the production function in equation 1 is given by:

$$c_Z(w_i, r_i) = r_i^{\beta} w_i^{1-\beta}. \tag{2}$$

w_i and r_i stand for the price per unit labor and the capital rental rate in country i. Since sector Z firms behave perfectly competitively, they sell good Z at price $p_Z = c_Z(w_i, r_i)$. Applying Shephard's Lemma to $c_Z(w_i, r_i)$ leads to the factor input coefficients for good Z:

$$a_{K,Z,i} = \beta \left(\frac{w_i}{r_i}\right)^{1-\beta} \quad \text{and} \quad a_{L,Z,i} = (1-\beta)\left(\frac{r_i}{w_i}\right)^{\beta},$$

where $a_{K,Z,i}$ stands for the capital input and $a_{L,Z,i}$ for the labor input per unit of good Z.

Intermediate goods v_1 and v_2 are produced according to the following Cobb–Douglas production functions:

$$v_1 = \frac{K_{1,H}^{\phi_1} L_{1,H}^{1-\phi_1}}{\phi_1^{\phi_1} (1-\phi_1)^{1-\phi_1}} \tag{3}$$

$$v_2 = \frac{K_{2,F}^{\phi_2} L_{2,F}^{1-\phi_2}}{\phi_2^{\phi_2} (1-\phi_2)^{1-\phi_2}}. \tag{4}$$

Remember that we assume that multinationals produce v_1 (v_2) in country H (F). The marginal cost functions which are dual to the production functions 3 and 4 are given by:

$$c_{v_1}(w_H, r_H) = r_H^{\phi_1} w_H^{1-\phi_1} \tag{5}$$

$$c_{v_2}(w_F, r_F) = r_F^{\phi_2} w_F^{1-\phi_2}. \tag{6}$$

Applying Shephard's Lemma to the marginal cost functions 5 and 6 leads to the following factor input coefficients for intermediate goods v_1 and v_2:

$$a_{K,v_m} = \phi_m \left(\frac{w_i}{r_i}\right)^{1-\phi_m} \quad \text{and} \quad a_{L,v_m} = (1-\phi_m)\left(\frac{r_i}{w_i}\right)^{\phi_m}, \quad m = 1, 2, \quad i = H, F,$$

where a_{K,v_m} stands for the capital input and a_{L,v_m} for the labor input per unit of v_m.

[7] Notice that we will introduce a time index t only when we explicitly describe the dynamics.

Intermediate goods v_1 and v_2 are assembled to a unique variety of the differentiated final good X according to the following Cobb–Douglas production function:

$$X = \frac{v_1^{\alpha} v_2^{1-\alpha}}{\alpha^{\alpha} (1-\alpha)^{1-\alpha}}. \tag{7}$$

The per unit cost function which is dual to the production function in equation 7 is given by:

$$c_X (w_H, w_F, r_H, r_F) = c_{v_1} (w_H, r_H)^{\alpha} c_{v_2} (w_F, r_F)^{1-\alpha}. \tag{8}$$

Finally, applying Shephard's Lemma to the marginal cost function 8 leads to the following input coefficients for good X:

$$a_{v_1,X} = \alpha \left[\frac{c_{v_2} (w_F, r_F)}{c_{v_1} (w_H, r_H)} \right]^{1-\alpha} \quad \text{and} \quad a_{v_2,X} = (1-\alpha) \left[\frac{c_{v_1} (w_H, r_H)}{c_{v_2} (w_F, r_F)} \right]^{\alpha},$$

where $a_{v_m,X}$, $m = 1, 2$, stands for the input of intermediate good v_m per unit of good X.

We make the following assumptions about the firms' technologies:

$$A: \quad \phi_1 \geq \beta \geq \phi_2; \qquad B: \quad \alpha > 0.5; \qquad C: \quad \phi_1 = 1 - \phi_2.$$

Assumption A implies that intermediate good v_1 is at least as capital intensive as the outside good Z, while intermediate good v_2 is at least as labor intensive than the outside good Z. Assumption B guarantees that the multinational firms' final output X is at least as capital intensive as the outside good Z. Assumptions A and B will be crucial for our results. Still, both assumptions are standard in the previous theoretical work on multinational activity and find empirical support (e.g., Markusen, 2002). Assumption C implies that ϕ_1 and ϕ_2 are symmetrically centered around 0.5. We impose assumption C for reasons of analytical tractability. Since the difference between ϕ_1 and ϕ_2 will be crucial for our results, assumption C does not restrict the generality of our setup.

3.3 Dynamic structure

We assume that households own firms. Thus, the representative household will represent households and firm owners. Including the time index t, the representative household's utility in a single period t in country i, $i = H, F$, is given by the following Cobb–Douglas function:

$$U_{i,t} = X_{i,t}^{\gamma} Z_{i,t}^{1-\gamma}, \quad 0 < \gamma < 1. \tag{9}$$

$X_{i,t}$ denotes a CES–aggregate of all consumed varieties of good X and $Z_{i,t}$ the consumption of good Z in country i in period t. The household chooses its consumption of goods X and

Z and investments of good Z in each period such that lifetime utility V is maximized. If ρ denotes the time discount rate, lifetime utility of the household is given by:

$$V_i = \sum_{t=0}^{\infty} \frac{u\left(U_{i,t}\right)}{(1+\rho)^t}, \tag{10}$$

where u represents the household's instantaneous utility function.

Country i's capital stock $K_{i,t}$ in period t is determined via the investment decision by the representative household. We assume that only good Z is used for investments. If δ stands for the depreciation rate for capital, investments into a country's capital stock in any period t of the steady state is given by:[8]

$$I_{i,t} = K_{i,t+1} - (1-\delta)\, K_{i,t}. \tag{11}$$

$I_{i,t}$ denotes the amount of good Z, which is invested in period t. Equation 11 implies that one unit of good Z, which is invested in period t, leads to one unit of capital in period $t+1$. The household owns the production factors and lends them out to firms for production. The steady state of the country is then described by several necessary first order conditions which determine the country's factor price ratio in the steady state:[9]

$$r_{i,t} + (1-\delta)\, p_{Z,i,t} = p_{K,i,t} \tag{12}$$

$$r_{i,t} = p_{Z,i,t} \left(\frac{\beta}{1-\beta}\frac{L_{Z,i,t}}{K_{Z,i,t}}\right)^{1-\beta} \tag{13}$$

$$w_{i,t} = p_{Z,i,t} \left(\frac{1-\beta}{\beta}\frac{K_{Z,i,t}}{L_{Z,i,t}}\right)^{\beta} \tag{14}$$

$$\frac{p_{K,i,t+1}}{1+\rho} = p_{Z,i,t}. \tag{15}$$

$p_{K,i,t}$ denotes the price per unit capital in country i, period t, and $L_{Z,i,t}$ and $K_{Z,i,t}$ the labor and capital input into sector Z of country i, period t.

Equation 12 is the arbitrage condition for the household's capital lending behavior: the household is only willing to lend out capital to firms if the capital rental rate $r_{i,t}$ plus the value of the remaining unit of capital in period $t+1$, which is given by $(1-\delta)\, p_{Z,i,t}$, at least equals the price per unit capital in t. Equations 13 and 14 are the usual conditions for a profit maximizing factor input choice by firms. Equation 15 denotes the Euler equation, which describes the dynamically optimizing behavior of the representative household: the representative household chooses its investment level such that, in the steady state, the

[8]Notice that the country's labor endowment is constant over time. Investments in the steady state therefore only compensate for depreciation.

[9]See also Baxter (1992), p. 738.

discounted value of a unit capital in $t+1$ equals the value of a unit of good Z in t.[10]

The time index t is omitted from now on since only the steady state is considered in the following. Equations 12–15 can be solved for the relative wage rate in the steady state:

$$\frac{w_i}{r_i} = (\rho+\delta)^{-1/(1-\beta)} . \tag{16}$$

3.4 Factor price equalization in the steady state

The assumption of identical technologies and time preferences in both countries implies that the parameters ρ, δ and β are identical in both countries, i.e. $\frac{w_H}{r_H} = \frac{w_F}{r_F}$ due to equation 16. Furthermore, costless trade of good Z leads to:

$$p_{Z,H} = r_H^{\beta} w_H^{1-\beta} = r_F^{\beta} w_F^{1-\beta} = p_{Z,F} \tag{17}$$

$$\iff \left(\frac{w_H}{r_H}\right)^{1-\beta} r_H = \left(\frac{w_F}{r_F}\right)^{1-\beta} r_F. \tag{18}$$

Since $\frac{w_H}{r_H} = \frac{w_F}{r_F}$ in the steady state, equation 18 implies that $r_H = r_F$ in the steady state. Thus, the wage rate must be identical in both countries in the steady state as well. The factor prices are therefore written without a country index in the following. Notice though that factor price equalization occurs *only in the steady state*. During the adjustment from one steady state to the other, factor prices may certainly differ between countries.

3.5 Horizontal versus vertical multinational firms

A single multinational firm with headquarters in country i, $i = H, F$, has two production plants, one in country H and one in country F. Each production plant produces either only intermediate good v_1 or only intermediate good v_2. Thus, multinationals with headquarters in country i import one type of the intermediate goods from the respective other country and assemble both intermediate goods to a unique variety of final good X in the country of headquarters.[11] The unique variety of good X is sold domestically and is exported.

In our comparative steady state analysis in section 5 we will derive our results for different values for the technology parameters ϕ_1 and ϕ_2. We will explicitly distinguish between the following two cases.

First, we will consider the case of $\phi_1 = 1-\phi_2 = 0.5$, i.e. intermediate goods v_1, v_2 and final good X are produced with identical technologies. Thus, if $\phi_1 = 1-\phi_2 = 0.5$ relative

[10] Notice that the Euler equation can also be interpreted as a "zero profit condition" for investments. Since good Z, which is used for investments, is evaluated at its market price p_Z, the steady state does not depend on the specific assumptions on the investor's intratemporal utility function 9 (Cobb–Douglas versus general CES), as long as the time discount rate ρ, the capital depreciation rate δ and the share parameter γ are given.

[11] Since trade and assembly of v_1 and v_2 to a unique variety of X are costless, the location of assembling is immaterial for our results. Thus, our results would not change if we allowed multinationals to assemble v_1 and v_2 to a unique variety of X in the country of sales.

factor demands of multinational firms in both countries are identical in the steady state. Thus, our setup with $\phi_1 = 1 - \phi_2 = 0.5$ reflects *horizontal* multinational activity.[12]

Second, we will consider the case of $\phi_1 = 1 - \phi_2 > 0.5$. In this case, intermediate good v_1 is produced capital intensively, while intermediate good v_2 is produced labor intensively. Thus, if $\phi_1 = 1 - \phi_2 > 0.5$ our setup reflects *vertical* multinational activity and multinational firms become "more vertical," the further away ϕ_1 and $1 - \phi_2$ are from 0.5. Since vertical multinational firms typically have an identical allocation of production activities across countries due to a cost savings motive (e.g., Markusen, 2002), we assume that *all* multinationals produce v_1 only in country H and v_2 only in country F.[13]

Charts 1 and 2 of figure 1 illustrate the allocation of production activities across countries for multinational firms. Chart 1 refers to multinationals with headquarters in country H, whereas chart 2 refers to multinationals with headquarters in country F.

Figure 1 — Allocation of production activities across countries

3.6 Demand

The representative household's utility in country i in a single period of the steady state is given by:[14]

$$U_i = X_i^{\gamma} Z_i^{1-\gamma}, \quad 0 < \gamma < 1, \tag{19}$$
$$\text{with} \quad Z_i = Z_{ii} + Z_{ji} \quad \text{and} \quad X_i = \left[N_i X_{ii}^{(\sigma-1)/\sigma} + N_j X_{ji}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}, \quad \sigma > 1.$$

σ stands for the elasticity of substitution between any two varieties of good X and N_i and N_j stand for the number of multinational firms with headquarters in countries i and j. X_{ii} stands for the supply of a production plant from country i to country i. X_{ji} stands for the supply of a production plant from country j to country i. Similarly, Z_{ii} stands for the supply of good Z from country i to country i and Z_{ji} stands for the supply of good Z from country j to country i.

We assume that $N_i + N_j$ is sufficiently large so that the market for good X is characterized by large–group monopolistic competition. Profit maximizing firms then supply their varieties of good X at price $p_X = \frac{\sigma}{\sigma-1} c_X$. Since factor prices are identical in both countries in the steady state, c_X and p_X do not get a country index.

[12] Notice though that multinational production would be quantitatively identical in the two countries only if we would have $\alpha = \phi_1 = 1 - \phi_2 = 0.5$, i.e. if the two intermediate goods not only had identical factor intensities, but also the same share in production of X.

[13] We keep this assumption for the allocation of production activities across countries also for the "horizontal" case of $\phi_1 = 1 - \phi_2 = 0.5$.

[14] We assume that the preference parameter γ is identical across countries. In an appendix, which is available upon request, we also consider the case of demand shocks and allow the parameter γ to differ across countries.

The price index which is dual to the CES–aggregate X_i is then given by:

$$P = \left(N_i\, p_X^{1-\sigma} + N_j\, p_X^{1-\sigma}\right)^{1/(1-\sigma)} = (N_i + N_j)^{1/(1-\sigma)}\, \frac{\sigma}{\sigma - 1}\, c_X\,(w, r)\,. \tag{20}$$

Let

$$M_i = L_i\, w + K_i\, r - \delta\, K_i\, p_Z \tag{21}$$

denote that part of aggregate factor income of country i, $i = H, F$, which is used for consumption. The term $\delta\, K_i$, $i = H, F$, stands for investments of good Z in the steady state (cf. equation 11). The *supply* = *demand*–conditions for a variety of good X then result as:

$$X_{ii} = \gamma\, p_X^{-\sigma}\, P^{\sigma-1}\, M_i = \gamma\, \frac{\sigma - 1}{\sigma}\, \frac{M_i}{(N_i + N_j)\; c_X\,(w, r)}, \quad i = H, F, \tag{22}$$

and, similarly,

$$X_{ij} = \gamma\, \frac{\sigma - 1}{\sigma}\, \frac{M_j}{(N_i + N_j)\; c_X\,(w, r)}, \quad i, j = H, F, \;\; i \neq j. \tag{23}$$

Notice that the left–hand sides of equations 22 and 23 denote the supply of a *single* production plant from country i to country i or j. The right–hand sides of equations 22 and 23 accordingly denote the demand in country i or j for a unique variety which is produced by a multinational firm with headquarters in country i.

The *supply* = *demand*–condition for good Z and country i can be derived as:

$$Z_{ii} + Z_{ji} = \frac{M_i}{p_Z}\, (1 - \gamma) + \delta\, K_i, \quad i, j = H, F, \;\; i \neq j. \tag{24}$$

3.7 Free entry condition

We assume that entry into sector X is unrestricted, i.e. a free entry condition for sector X has to hold in each period of the steady state. The free entry condition equalizes total markup revenue of a single multinational with total fixed costs of this firm:

$$(p_X - c_X)\; (X_{ii} + X_{ij}) = r\; (F_{HQS+PP} + F_{PP})\,. \tag{25}$$

$p_X - c_X$ stands for the markup revenue per unit of good X sales. $X_{ii} + X_{ij}$ denotes total sales of the firm. F_{HQS+PP} stands for the fixed capital input in the country of the firm's headquarters, and it is used for producing headquarter services (HQS) and for maintaining the production plant (PP) in the country of headquarters. F_{PP} stands for the fixed capital input for maintaining the affiliate abroad. The term $r\; (F_{HQS+PP} + F_{PP})$ accordingly denotes total fixed costs of a single multinational firm.

Substituting the expressions for X_{ii} and X_{ij} (equations 22 and 23) into equation 25 and considering that $p_X = \frac{\sigma}{\sigma-1}\, c_X$, we can simplify the free entry condition to:

$$\gamma\, \frac{M_i + M_j}{\sigma\; (N_i + N_j)} = r\; (F_{HQS+PP} + F_{PP})\,. \tag{26}$$

3.8 Balance of payments equation

Countries can trade the varieties of good X, the homogeneous good Z and intermediate goods v_1 and v_2.[15] In addition, multinationals with headquarters in country i earn monopolistic profits in country j, with $i, j = H, F$, $i \neq j$. Notice that the varieties of good X are traded even between completely identical countries due to Dixit–Stiglitz preferences for good X.

Country H's imports of intermediate good v_2 are equal to $a_{v_2,X}\ (X_{HH} + X_{HF})\ N_H$, where $a_{v_2,X}$ denotes the input of v_2 per unit of X and $(X_{HH} + X_{HF})\ N_H$ denotes total production of X in country H. Similarly, country F's imports of intermediate good v_1 are equal to $a_{v_1,X}\ (X_{FF} + X_{FH})\ N_F$, where $a_{v_1,X}$ denotes the input of v_1 per unit of X and $(X_{FF} + X_{FH})\ N_F$ denotes total production of X in country F.

Thus, the balance of payments equation results as:

$$\begin{aligned} & Z_{HF} c_Z + a_{v_1,X}\ (X_{FF} + X_{FH})\ N_F\, c_{v_1} + X_{HF}\, N_H\, p_X - (p_X - c_X)\ X_{HF}\, N_H \\ = \ & Z_{FH} c_Z + a_{v_2,X}\ (X_{HH} + X_{HF})\ N_H\, c_{v_2} + X_{FH}\, N_F\, p_X - (p_X - c_X)\ X_{FH}\, N_F. \end{aligned} \tag{27}$$

Considering the input coefficients from subsection 3.2 and the terms for X_{ii} and X_{ij} from subsection 3.6, equation 27 can be simplified to:

$$Z_{HF} - Z_{FH} \ = \ \frac{\gamma}{c_Z}\, \frac{\sigma - 1}{\sigma}\, \left[M_H - \alpha\, (M_H + M_F)\right]. \tag{28}$$

Equation 28 illustrates the following. If $\phi_1 = 1 - \phi_2 = \alpha = 0.5$ and $L_H = L_F$, i.e. if countries are perfectly symmetric, then $M_H = \alpha(M_H + M_F)$ and trade of good Z is zero. This implies that net trade of intermediate goods is also zero and only varieties of the final good are traded. Thus, if countries are perfectly symmetric, our setting mimics a setting in which each of the two production plants produces the final good only for the local market.

3.9 Factor market equilibrium conditions

The factor market equilibrium conditions for both countries result as follows:[16]

$$a_{L,v_1}\, a_{v_1,X}\, [(X_{HH} + X_{HF})\, N_H + (X_{FF} + X_{FH})\, N_F] + a_{L,Z}\, (Z_{HH} + Z_{HF}) \ = \ L_H \tag{29}$$

$$\begin{aligned} & a_{K,v_1}\, a_{v_1,X}\, [(X_{HH} + X_{HF})\, N_H + (X_{FF} + X_{FH})\, N_F] \\ & \qquad + a_{K,Z}\, (Z_{HH} + Z_{HF}) + N_H F_{HQS+PP} + N_F F_{PP} \ = \ K_H \end{aligned} \tag{30}$$

[15]Strictly speaking, v_1 and v_2 are traded within the firm. However, production of intermediate goods leads to factor income, which leads to demand for final goods in the country of production. Trade of intermediate goods therefore has to be considered as well in the balance of payments equation.

[16]Remember that X_{HH}, X_{HF}, X_{FF}, X_{FH} stand for the supply of a *single* multinational firm and that intermediate good v_1 (v_2) is produced in country H (F).

$$a_{L,v_2}\, a_{v_2,X}\left[\left(X_{FF}+X_{FH}\right)N_F+\left(X_{HH}+X_{HF}\right)N_H\right]+a_{L,Z}\left(Z_{FF}+Z_{FH}\right)\;=\;L_F \qquad (31)$$

$$a_{K,v_2}\, a_{v_2,X}\left[\left(X_{FF}+X_{FH}\right)N_F+\left(X_{HH}+X_{HF}\right)N_H\right] \\ +a_{K,Z}\left(Z_{FF}+Z_{FH}\right)+N_F F_{HQS+PP}+N_H F_{PP}\;=\;K_F \qquad (32)$$

Equations 29 and 31 (30 and 32) stand for the labor (capital) market equilibrium conditions for countries H and F, respectively.

4 Steady state general equilibrium

The steady state general equilibrium for this two–country world is characterized by the following five conditions:

i) equation 16 since countries are in the steady state

ii) *supply* = *demand* for each variety of good X (equations 22 and 23) and for the homogeneous good Z (equation 24)

iii) the balance of payments equation (equation 28)

iv) the free entry condition for sector X (equation 26)

v) the factor market equilibrium conditions for each country (equations 29–32).

Conditions *i*)–*iii*) can be substituted into the four factor market equilibrium conditions, while condition *iv*) can be substituted into the two capital market equilibrium conditions. Thus, we can represent the steady state general equilibrium of this two country world by a system of four equations (equations 29–32) with four variables (K_H, K_F, N_H, N_F).

In order to simplify the algebra, without affecting the general implications of our results, we impose two normalizations. First, we set the capital depreciation rate δ equal to zero. Since each country's labor endowment is constant over time, capital expenditures *in the steady state* are therefore zero as well. Thus, in the steady state, the representative household demands good Z only for consumption purposes. If the persistent exogenous shock shifts the country to a new steady state with a larger (smaller) capital stock, capital expenditures are temporarily positive (negative). The main driving mechanism for our results will be the positive relationship between capital intensity in production and a country's relative capital endowment in the steady state. This positive relationship is present as long as $\delta < 1$. Second, we set β equal to 0.5. While the ranking $\phi_1 > \beta > \phi_2$ is crucial for our results, setting $\beta = 0.5$ simplifies the algebra considerably.[17]

[17]Proofs for the more general setting are available from the authors upon request.

If we consider the input coefficients from subsection 3.2, we can simplify equations 29–32 to the following system of equations:

$$M_H \left[\left(\frac{1}{2} - \phi_1 \right) \gamma\alpha \frac{\sigma - 1}{\sigma} + \frac{\sigma - \gamma}{2\sigma} \right] + M_F \left(\frac{1}{2} - \phi_1 \right) \gamma\alpha \frac{\sigma - 1}{\sigma} = L_H \qquad (33)$$

$$(N_H + N_F)\, \phi_1 \alpha(\sigma - 1)(F_{HQS} + F_{PP}) + N_H F_{HQS} + N_F F_{PP}$$
$$- M_H \frac{(1-\alpha)\gamma + (\alpha\gamma - 1)\sigma}{2\sigma} - M_F \gamma \frac{\sigma - 1}{2\sigma} \alpha = K_H \qquad (34)$$

$$M_H \left(\phi_1 - \frac{1}{2} \right) \gamma \frac{(1-\alpha)(\sigma - 1)}{\sigma} + M_F \left[\left(\phi_1 - \frac{1}{2} \right) \gamma \frac{(1-\alpha)(\sigma - 1)}{\sigma} - \frac{\gamma - \sigma}{2\sigma} \right] = L_F \quad (35)$$

$$(N_H + N_F)\, (1 - \phi_1)(1-\alpha)(\sigma - 1)(F_{HQS} + F_{PP}) + N_F F_{HQS} + N_H F_{PP}$$
$$+ M_F \frac{(1-\gamma)\sigma + (\sigma - 1)\alpha\gamma}{2\sigma} - M_H \gamma \frac{\sigma - 1}{2\sigma}(1 - \alpha) = K_F. \quad (36)$$

Notice that M_i stands for aggregate factor income in the steady state in country i, $i = H, F$. Since labor in either country can be taken as numéraire and since $\frac{r}{w}$ in the steady state is determined by parameters, equations 33–36 are linear in the variables K_H, K_F, N_H and N_F.

Once K_H, K_F, N_H and N_F are known, the steady state values of all quantity variables and relative prices can be derived:

- the relative price of capital follows from equation 16;
- the relative prices of intermediate goods v_1 and v_2 follow from equation 5 and 6, the relative prices of the goods Z and X follow from equations 2 and 8;
- aggregate factor income in terms of the numéraire good in either country follows from equation 21;
- demand for the varieties of good X follows from equations 22 and 23, aggregate demand for good Z follows from equation 24;
- trade in the varieties of good X follows from equation 23, trade in good Z follows from equation 28;
- utility of either country in a single period of the steady state follows from substituting the consumed quantities into equation 19.

5 Comparative steady state analysis

The labor market equilibrium conditions (equations 33 and 35) alone are sufficient to solve for the countries' capital stocks K_H and K_F in the steady state since they do not depend on the variables N_H and N_F. Thus, we can perform our comparative steady state analysis already with the help of equations 33 and 35.

We will disturb the steady state of the two–country world by a persistent shock to country–wide labor productivity, which hits the two countries completely symmetrically. If we interpret L_H and L_F as *effective* labor endowments, a persistent shock to country–wide labor productivity can be represented by dL_H and dL_F, where d denotes the differential operator. Thus, in the case of a symmetric shock we have $dL_H = dL_F \neq 0$.

In order to determine how capital expenditures in the two countries react to these permanent shocks to aggregate labor productivity, we analyze how the capital endowments K_H and K_F react to these shock. If a country's capital stock in the new steady state is larger (smaller) than in the initial steady state, we can conclude that capital expenditures temporarily increase (decrease) due to the shock. Totally differentiating equations 33 and 35 leads to:

$$\begin{pmatrix} \frac{\sigma-\gamma-(2\phi_1-1)\alpha\gamma(\sigma-1)}{2\sigma}r & \left(\frac{1}{2}-\phi_1\right)\gamma\frac{\alpha(\sigma-1)}{\sigma}r \\ \left(\phi_1-\frac{1}{2}\right)\gamma\frac{(1-\alpha)(\sigma-1)}{\sigma}r & \frac{(1-\gamma)\sigma+[\alpha+2(1-\alpha)\phi_1]\gamma(\sigma-1)}{2\sigma}r \end{pmatrix}\begin{pmatrix} dK_H \\ dK_F \end{pmatrix}$$
$$= \begin{pmatrix} \frac{\sigma+\gamma+(2\phi_1-1)\alpha\gamma(\sigma-1)}{2\sigma}dL_H - \left(\frac{1}{2}-\phi_1\right)\gamma\alpha\frac{\sigma-1}{\sigma}dL_F \\ \left(\frac{1}{2}-\phi_1\right)\gamma\frac{(1-\alpha)(\sigma-1)}{\sigma}dL_H + \frac{\sigma+\gamma+(1-2\phi_1)\gamma(1-\alpha)(\sigma-1)}{2\sigma}dL_F \end{pmatrix}. \quad (37)$$

We can use equation 37 to derive our comparative steady state result. If both countries are hit symmetrically by a shock to country–wide labor productivity, propositions 1 describes the adjustment of capital stocks K_H and K_F:

Proposition 1 *If assumptions A–C for the firms' production technologies hold and if countries are hit by a symmetric positive shock to country–wide labor productivity* ($dL_H = dL_F > 0$)*, we have the following adjustment of the countries' capital stocks K_H and K_F:*

- *K_H increases, and the increase in K_H becomes larger if ϕ_1 increases.*
- *K_F increases if $\phi_1 = 1 - \phi_2 = 0.5$, i.e. if multinationals produce with identical factor intensities in countries H and F. The increase in K_F becomes smaller if ϕ_2 decreases.*
- *K_F decreases if ϕ_2 is sufficiently small, i.e. if multinational production in country F is sufficiently labor intensive.*

Proof. See the appendix. ■

Remember that the case of $\phi_1 = 1 - \phi_2 = 0.5$ reflects horizontal multinational activity. The case of $\phi_1 = 1 - \phi_2 > 0.5$ — i.e. intermediate good v_1 (produced in country H) is produced capital intensively, while intermediate good v_2 (produced in country F) is produced labor intensively — reflects vertical multinational activity.

Proposition 1 implies that domestic and foreign capital expenditures are *complements* if multinational activity is *horizontal*. The positive relationship between domestic and foreign capital expenditures becomes weaker if the factor intensities of multinational production become more different across countries. Domestic and foreign capital expenditures eventually become *substitutes* if multinational activity is sufficiently *vertical*. Figure 2 illustrates these results. Domestic and foreign capital expenditures are substitutes if K_F decreases due to the shock.[18]

Figure 2 — Comparative steady state results

In order to understand the intuition behind these results, notice that an increase in L_H and L_F increases factor incomes M_H and M_F. This, in turn, has two counteracting effects on capital expenditures in either country:

First, if we ignore for the moment any changes in the trade pattern between countries, the increase in M_H and M_F increases demand and, thus, production of goods Z and X in both countries. Since all goods use capital and labor, the increase in production of goods Z and X increases capital demand. Thus, $\frac{r}{w}$ ceteris paribus increases, which increases capital expenditures in both countries and, finally, K_H and K_F. If $\phi_1 = 1 - \phi_2 = 0.5$, the capital intensity of multinational production is identical in both countries, which implies that K_H and K_F increase by an identical amount. However, if multinational production in country H (country F) becomes more (less) capital intensive, i.e. if $\phi_1 = 1 - \phi_2 > 0.5$, K_H (K_F) increases by a larger (smaller) amount.

Second, the balance of payments equation (equation 28) shows that the increase in M_H and M_F also influences the trade pattern between countries. The change of the trade pattern becomes most obvious if α is equal to 0.5, i.e. if v_1 and v_2 have identical shares in the production of good X. Equation 28 then shows that net exports of good Z from country H to country F increase if M_H increases by more than M_F — which is the case if $\phi_1 = 1 - \phi_2 > 0.5$. Thus, the adjustment of the trade pattern ceteris paribus decreases the capital intensity in production in both countries: in country H resources shift from sector v_1 to sector Z, while in country F resources shift from sector Z to sector v_2. Thus, in both countries relative capital demand decreases due to the adjustment of the trade pattern, which implies that capital expenditures ceteris paribus decrease in both countries.

What is the *net* effect on each country's capital stock? The first effect is positive for

[18]Notice that the $\frac{dK_F}{dL}$–curve actually becomes negative only if multinationals are sufficiently large relative to factor markets in country F, i.e. if α is sufficiently close to its lower bound 0.5 (see the appendix). In our empirical analysis we show that, on average, US multinationals are apparently sufficiently large relative to foreign factor markets, so that domestic and foreign capital expenditures become substitutes if the factor intensities in domestic and foreign production are sufficiently different.

both countries, while the second effect is negative for both countries. The net effect is always positive for country H (remember that, due to the first effect, the increase in K_H is always at least as large as the increase in K_F). The net effect is also positive for country F if $\phi_1 = 1 - \phi_2 = 0.5$, i.e. if multinational activity is horizontal. However, the second effect may dominate the first one for country F if v_2 is produced sufficiently labor intensively.

The intuition for our results also highlights the important components of our setup. First, without multinational activity, the factor intensities of sector X production in both countries would be identical. Thus, in the absence of multinational activity, we could never have the result that a symmetric shock to both countries has an asymmetric effect on factor incomes M_H and M_F. However, an asymmetric effect of the shock on M_H and M_F is necessary in order to trigger an adjustment of the trade pattern. Second, without intra–industry trade, countries would only interact via Heckscher–Ohlin trade. However, in the presence of Heckscher–Ohlin trade, we could never have a complementary relationship between domestic and foreign capital expenditures since it is a well–known result, that the world–wide capital stock is constant in a dynamic Heckscher–Ohlin setting, while only the distribution of capital across countries is indeterminate (Bond et al., 2003).

6 Some evidence

6.1 Empirical model

In our empirical model we follow the approach of Desai et al. (2005) and regress the domestic capital expenditures of multinational firms on the foreign capital expenditures of the same firms. This approach allows for a direct comparison of our empirical results with our theoretical results. Notice that in our theoretical model domestic and foreign capital expenditures are determined simultaneously. Thus, our results should be interpreted as partial correlations between these two variables.

Data for the empirical analysis is taken from the website of the US Bureau of Economic Analysis. We constructed a panel with 47 manufacturing and non–manufacturing sectors (see table $A1$ in the appendix) and the 12 most recent years for which data is available (1999–2010). The BEA data divides the operations of multinational firms into the operations of the American parent company and its foreign affiliates. For the data of the foreign affiliates, the BEA allows to choose between data for majority owned foreign affiliates only or for all foreign affiliates, where the latter are defined as outward foreign direct investment with ownership or control by the parent company of at least 10%.[19] We have chosen to use the data for the majority owned foreign affiliates. As initial year, 1999 is taken since the BEA switched from

[19] A more complete description of the BEA data on US multinationals can be found in Slaughter (2000).

SIC to the NAICS classification in that year.

In order to test the previously derived hypotheses, we construct four variables at the sector level. The dependent variable is *Domestic Investment* (*DI*), defined as domestic capital expenditures of US parent companies as part of total value added of US parent companies. The independent variables are (*i*) *Foreign Investment* (*FI*), defined as foreign capital expenditures of US parent companies as part of total value added of US parent companies; (*ii*) *Relative Wage* $\left(\frac{w_{par.}}{w_{aff.}}\right)$, defined as the average wage at US parent companies, divided by the average wage at US affiliate firms;[20] (*iii*) *Relative Labor Share* $\left(\frac{LS_{par.}}{LS_{aff.}}\right)$, defined as total labor costs as part of total value added of US parent companies (subscript *par.*), divided by total labor costs as part of total value added of US affiliate firms (subscript $aff.$). Table 1 reports the descriptive statistics for the dependent variable and independent variables. As manufacturing and non–manufacturing sectors may be different in terms of the relation between domestic and foreign investment, the table also shows descriptive statistics for these sectors separately. Table $A1$ in the appendix reports the mean values for all variables and for all sectors separately.[21] Notice that a smaller value for $\frac{LS_{par.}}{LS_{aff.}}$ or a larger value for $\frac{w_{par.}}{w_{aff.}}$ implies that the affiliate produces more labor intensively, compared to the parent company.

Table 1 — Descriptive statistics

The theoretical results suggest that the relationship between domestic and foreign investments depends on whether multinationals' activities are horizontal or vertical. For that reason we construct interaction terms between *Foreign Investment* and the two variables, which reflect differences in factor intensities between domestic and foreign production ($\frac{w_{par.}}{w_{aff.}}$ and $\frac{LS_{par.}}{LS_{aff.}}$).

Let β_{FI} denote the estimated coefficient for *Foreign Investment* (FI), $\beta_{FI\times\frac{w_{par.}}{w_{aff.}}}$ the estimated coefficient for the interaction term between FI and $\frac{w_{par.}}{w_{aff.}}$ and $\beta_{FI\times\frac{LS_{par.}}{LS_{aff.}}}$ the estimated coefficient for the interaction term between FI and $\frac{LS_{par.}}{LS_{aff.}}$. If we include the first interaction term, domestic and foreign capital expenditures are substitutes (complements) if the term $\beta_{FI} + \beta_{FI\times\frac{w_{par.}}{w_{aff.}}} \times \frac{w_{par.}}{w_{aff.}}$ is negative (positive). On the other hand, if we include the second interaction term, domestic and foreign capital expenditures are substitutes (complements) when the term $\beta_{FI} + \beta_{FI\times\frac{LS_{par.}}{LS_{aff.}}} \times \frac{LS_{par.}}{LS_{aff.}}$ is negative (positive). Theory suggests that

[20] Notice that our theoretical model predicts factor price equalization only for the steady state. If domestic and foreign investment adjust due to a movement from one steady state to the other, factor prices differ between countries also in our theoretical model. We have calculated the average wage as total labor costs, divided by total employment at the parent company or the affiliate firm, respectively.

[21] Since the sectors with NAICS code 3343 (audio and video equipment) and 55 (management of nonbank companies and enterprises) report values for $LS_{aff.}$ larger than unity or negative, we have excluded these two sectors from our empirical analysis.

$\beta_{FI\times\frac{w_{par.}}{w_{aff.}}} < 0$ and $\beta_{FI\times\frac{LS_{par.}}{LS_{aff.}}} > 0$.

We denote the threshold value for the relative wage above which domestic and foreign investments become substitutes by $\left(\frac{w_{par.}}{w_{aff.}}\right)^*$, and it results as $\left(\frac{w_{par.}}{w_{aff.}}\right)^* = \frac{-\beta_{FI}}{\beta_{FI\times\frac{w_{par.}}{w_{aff.}}}}$. The threshold value for the relative labor share below which domestic and foreign investments become substitutes results as $\left(\frac{LS_{par.}}{LS_{aff.}}\right)^* = \frac{-\beta_{FI}}{\beta_{FI\times\frac{LS_{par.}}{LS_{aff.}}}}$.

6.2 Empirical results

Columns (1), (4) and (7) of table 2 show the results of the basic panel regression with year and sector fixed effects, but without interaction effects.[22] If we consider the total sample (column (1)), the partial correlation between domestic and foreign investments is insignificant. Thus, taking more recent data, we are initially not able to replicate the findings by Desai et al. (2005), who have found that domestic and foreign capital expenditures of multinational firms are complements.

Table 2 — Empirical results

As a first test for our theoretical model, we split our sample into manufacturing and non–manufacturing sectors. The descriptive statistics (see table 1) show that manufacturing and non–manufacturing sectors differ to some extent concerning the two variables, which reflect differences in factor intensities between domestic and foreign production $\left(\frac{w_{par.}}{w_{aff.}} \text{ and } \frac{LS_{par.}}{LS_{aff.}}\right)$. While the variable $\frac{w_{par.}}{w_{aff.}}$ suggests that the production structure of multinationals from non–manufacturing sectors is, on average, more horizontal than the production structure of multinationals from manufacturing sectors, the variable $\frac{LS_{par.}}{LS_{aff.}}$ suggests the opposite. In order to find evidence for a difference between manufacturing and non–manufacturing sectors, we run the basic panel regression for manufacturing and non–manufacturing sectors separately. Columns (4) and (7) of table 2 show that the relationship between domestic and foreign capital expenditures is complementary for multinationals from non–manufacturing and manufacturing sectors, which is in line with Desai et al. (2005). However, by estimating an interaction term between *Foreign Investment* (FI) and a dummy for manufacturing sectors in the full sample we can show that the complementary relationship is significantly weaker for manufacturing sectors, as compared to non–manufacturing sectors ($p < 0.05$).[23]

Next, we provide more rigorous empirical evidence for our theory by taking into account the interaction between FI and the two variables, which reflect differences in factor intensities

[22] The Hausman test has shown that fixed effects regressions are preferred to random effects regressions in all our specifications. Time and sector dummies are not reported, but are significant in most of our specifications.

[23] These additional results are available from the authors upon request.

between domestic and foreign production. First, consider the interaction between FI and $\frac{w_{par.}}{w_{aff.}}$ (columns (2), (5) and (8)). As expected, the estimated values of β_{FI} and $\beta_{FI\times\frac{w_{par.}}{w_{aff.}}}$ have a positive and a negative sign, respectively, confirming the hypothesis that the relation between domestic and foreign investments becomes substitutable when multinational activity becomes sufficiently vertical (a larger value for $\frac{w_{par.}}{w_{aff.}}$). The critical value for $\frac{w_{par.}}{w_{aff.}}$, above which domestic and foreign investments become substitutes results as $\frac{-\beta_{FI}}{\beta_{FI\times\frac{w_{par.}}{w_{aff.}}}} = 3.496$ for the entire sample, 3.961 for non–manufacturing sectors and 3.2 for manufacturing sectors. These values are significantly different from zero at the 1% level.[24] Considering that the maximum value for $\frac{w_{par.}}{w_{aff.}}$ in non–manufacturing sectors is 3.484 (see table 1), these results imply that we do not expect to see a substitutional relationship between domestic and foreign investment for multinationals from non–manufacturing sectors. However, for manufacturing sectors the critical value for $\frac{w_{par.}}{w_{aff.}}$ is well below the maximum value for $\frac{w_{par.}}{w_{aff.}}$ in our sample. Thus, we expect to see a substitutional relationship between domestic and foreign investment for sufficiently vertical multinationals from manufacturing sectors.

As a robustness check, we instead interact FI with $\frac{LS_{par.}}{LS_{aff.}}$ (columns (3), (6) and (9)). Only when we restrict the sample to non–manufacturing sectors the interaction term between foreign investment and the relative labor share becomes significant (column 6). The implied threshold value for $\frac{LS_{par.}}{LS_{aff.}}$, below which domestic and foreign investments become substitutes, is negative (-1.643), but it is not statistically significantly different from zero.[25] Considering that the minimum value for $\frac{LS_{par.}}{LS_{aff.}}$ in non–manufacturing sectors is 0.526, also these results imply that we do not expect to see a substitutional relationship between domestic and foreign investments for multinationals from non–manufacturing sectors.

The results of the regressions with the interaction terms confirm that the relationship between domestic and foreign investments crucially depends on the multinationals' production technologies. Especially the interaction term with the relative wage shows that manufacturing sectors may show a substitutional relationship between domestic and foreign investments, while non–manufacturing sectors only show a complementary relationship between these two variables.

7 Conclusions

Our paper has shown that the link between domestic and foreign capital expenditures of multinational firms depends on the firms' production technologies. In the theoretical general equilibrium model we derive a complementary relationship between domestic and foreign

[24]The χ^2–statistics with one degree of freedom result as 97.13, 56.56 and 104.35, respectively.
[25]The χ^2–statistic with one degree of freedom results as 0.53.

capital expenditures if multinationals produce with identical technologies at home and abroad (reflects horizontal multinational activity). However, if the factor intensity of multinational production at home differs sufficiently from the factor intensity of multinational production abroad (reflects vertical multinational activity), the relationship between domestic and foreign capital expenditures becomes substitutional.

At first sight, especially the result of complementarity under horizontal multinational activity runs counter the intuition that would follow from a setting with fixed aggregate capital expenditures. In such a setting, an increase in foreign capital expenditures necessarily leads to a decrease in domestic capital expenditures. However, in our general equilibrium setting with endogenous capital expenditures, a firm's capital expenditures in either country are solely determined by the relative returns to capital in the respective country. The relative returns to capital finally depend on relative factor demands, which are influenced by the multinationals' production activities. Since horizontal multinationals have identical production activities in both countries, they influence factor markets in both countries in an identical way.

If multinationals are vertical, in contrast, any adjustment of multinational production changes relative capital demand and, thus, relative factor prices in countries into opposite directions. Therefore, we get a substitutional relationship between domestic and foreign capital expenditures if multinationals are vertical.

We test our theoretical implications with a panel of US multinational firms and find empirical support. Our results show that domestic and foreign capital expenditures of multinational firms are complements if multinationals produce with similar factor intensities at home and abroad. This relationship may switch to substitutional if multinationals produce with sufficiently different technologies.

Following our analysis, it is crucial to know the multinationals' production technologies in order to evaluate how a multinational's foreign capital expenditures are related to those at home.

Future research could extend our analysis into two directions. First, it could also consider adjustments at the extensive margin of multinational activity and explicitly consider trade costs. It would be interesting to see how these adjustments at the extensive margin impact the link between domestic and foreign capital expenditures we have identified. Second, future research could test our hypotheses with firm level data in order to allow for a more precise distinction between horizontal and vertical multinational activity.

Appendix — proof of proposition 1

Solving equation 37 for $\frac{dK_H}{dL}$ and $\frac{dK_F}{dL}$, with $dL = dL_H = dL_F$, leads to:

$$\frac{dK_H}{dL} = \frac{\gamma\left[\sigma(2\phi_1-\alpha)+\alpha\gamma+(2\alpha-1)(\sigma-\gamma)\phi_1\right](\sigma-1)+(\sigma+\gamma)\frac{1}{2}\sigma(1-\gamma)}{\left[(\sigma-1)\gamma\left(\phi_1+\alpha-2\alpha\phi_1\right)+(1-\gamma)\sigma\frac{1}{2}\right](\sigma-\gamma)r} \quad \text{(A–1)}$$

$$\frac{dK_F}{dL} = \frac{(\sigma-1)\left[(3-2\alpha)\sigma\gamma(2\phi_1-1)+(2\alpha-1)2\gamma^2\phi_1-2\alpha\gamma^2\right]-\sigma^2+\sigma\gamma^2}{2\left\{(\sigma-1)\gamma\left[(2\alpha-1)\phi_1-\alpha\right]+(\gamma-1)\sigma\frac{1}{2}\right\}(\sigma-\gamma)r}. \quad \text{(A–2)}$$

Equation A–1 shows that $\frac{dK_H}{dL}$ is positive under assumptions A–C for the technologies (notice that $\alpha+\phi_1-2\alpha\phi_1 > 0$). Equation A–2 shows that $\frac{dK_F}{dL}$ can be positive or negative, depending on the values for ϕ_1 and α. In order to derive the $\frac{dK_H}{dL}$ and $\frac{dK_F}{dL}$–curves in figure 2 we start by calculating the following second and third–order partial derivatives.

First, the partial derivatives of $\frac{dK_H}{dL}$ with respect to ϕ_1 are given as follows:

$$\left.\frac{d^2K_H}{dLd\phi_1}\right|_{\phi_1>0.5} = \frac{8(\sigma-1)\gamma\sigma\alpha}{\left[(\gamma-1)\sigma+(2\alpha\phi_1-\alpha-\phi_1)2\gamma(\sigma-1)\right]^2 r} > 0 \quad \text{(A–3)}$$

$$\left.\frac{d^3dK_H}{dL\left(d\phi_1\right)^2}\right|_{\phi_1>0.5} = \frac{32(2\alpha-1)(\sigma-1)^2\alpha\sigma\gamma^2}{\left[(1-\gamma)\sigma+(\alpha+\phi_1-2\alpha\phi_1)2\gamma(\sigma-1)\right]^3 r} > 0. \quad \text{(A–4)}$$

Second, the first and second order partial derivatives of $\frac{dK_F}{dL}$ with respect to ϕ_1 result as (notice that $\phi_1 = 1-\phi_2$ due to assumption C; thus, an increase in ϕ_1 implies that intermediate good v_2 becomes more labor intensive):

$$\left.\frac{d^2K_F}{dLd\phi_1}\right|_{\phi_1>0.5} = \frac{8(\alpha-1)(\sigma-1)\gamma\sigma}{\left[(\gamma-1)\sigma+(2\alpha\phi_1-\alpha-\phi_1)2\gamma(\sigma-1)\right]^2 r} < 0 \quad \text{(A–5)}$$

$$\left.\frac{d^3K_F}{dL\left(d\phi_1\right)^2}\right|_{\phi_1>0.5} = (-32)\frac{(\sigma-1)^2(\alpha-1)(2\alpha-1)\sigma\gamma^2}{\left[(\alpha+\phi_1-2\alpha\phi_1)2\gamma(1-\sigma)+\sigma(\gamma-1)\right]^3 r} < 0. \quad \text{(A–6)}$$

Finally, we can calculate a critical value for ϕ_1 (denoted by $\phi_1^{crit.}$). $\phi_1^{crit.}$ is defined as follows: if $\phi_1 > \phi_1^{crit.}$, then $\frac{dK_F}{dL} < 0$ and if $\phi_1 < \phi_1^{crit.}$, then $\frac{dK_F}{dL} > 0$. Thus, if $\phi_1 = 1-\phi_2 > \phi_1^{crit.}$, the factor intensities in the production of v_1 and v_2 are sufficiently different so that domestic and foreign capital expenditures become substitutes. $\phi_1^{crit.}$ is given as follows:

$$\phi_1^{crit.} = \frac{\sigma^2-\sigma\gamma^2-(\sigma-1)\left[-2\alpha\gamma^2-\sigma\gamma(-2\alpha+3)\right]}{(\sigma-1)\left[2\sigma\gamma(-2\alpha+3)+2\gamma^2(2\alpha-1)\right]}.$$

We can show the following with respect to $\phi_1^{crit.}$:

i) $\phi_1^{crit.}$ is larger than 0.5: $\phi_1^{crit.} > 0.5 \Longleftrightarrow \sigma^2-\gamma^2 > 0.$

ii) $\phi_1^{crit.}$ is smaller than 1 if $\alpha = 0.5$ and $\gamma = 1$: $\left.\phi_1^{crit.}\right|_{\alpha=0.5,\gamma=1} < 1 \Longleftrightarrow 1-\sigma < 0.$

iii) the partial derivatives of $\phi_1^{crit.}$ with respect to α and γ are given as follows:

$$\frac{\partial\phi_1^{crit.}}{\partial\alpha} = \frac{(\gamma-\sigma)^2(\sigma+\gamma)}{(3\sigma-\gamma-2\alpha\sigma+2\alpha\gamma)^2(\sigma-1)\gamma} > 0,$$

$$\frac{\partial\phi_1^{crit.}}{\partial\gamma} = \sigma\frac{(1-2\alpha)2\sigma\gamma+(\sigma^2+\gamma^2)(2\alpha-3)}{2(3\sigma-\gamma-2\alpha\sigma+2\alpha\gamma)^2(\sigma-1)\gamma^2} < 0.$$

Thus, for any given factor share parameters $\phi_1 = 1-\phi_2$ it is more likely that domestic and foreign capital expenditures are substitutes, the smaller is α and the larger is γ.

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Figure 1: Allocation of production activities across countries

chart 1: Multinational firms with headquarters in country *H*:

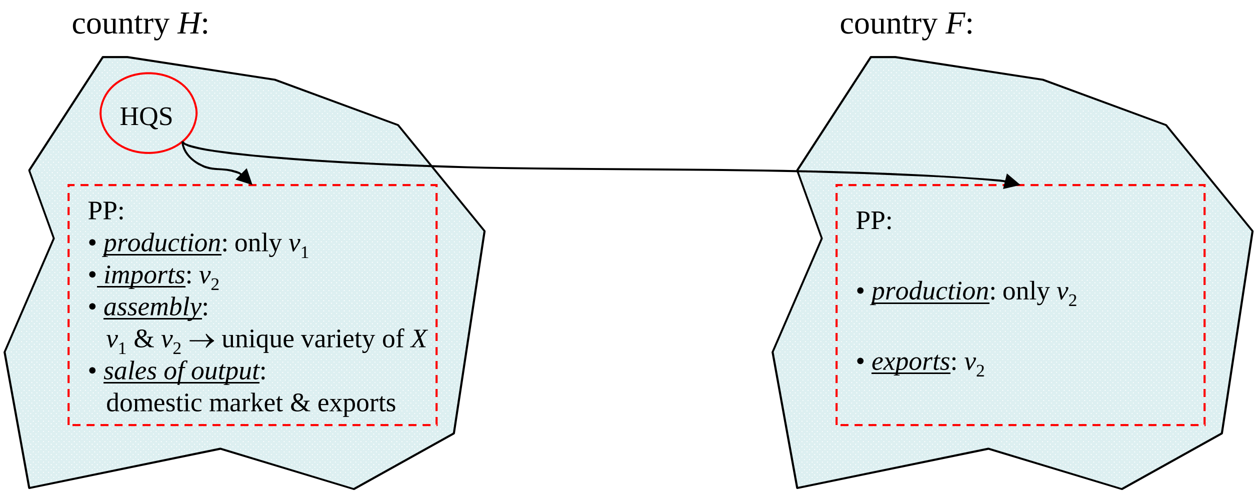
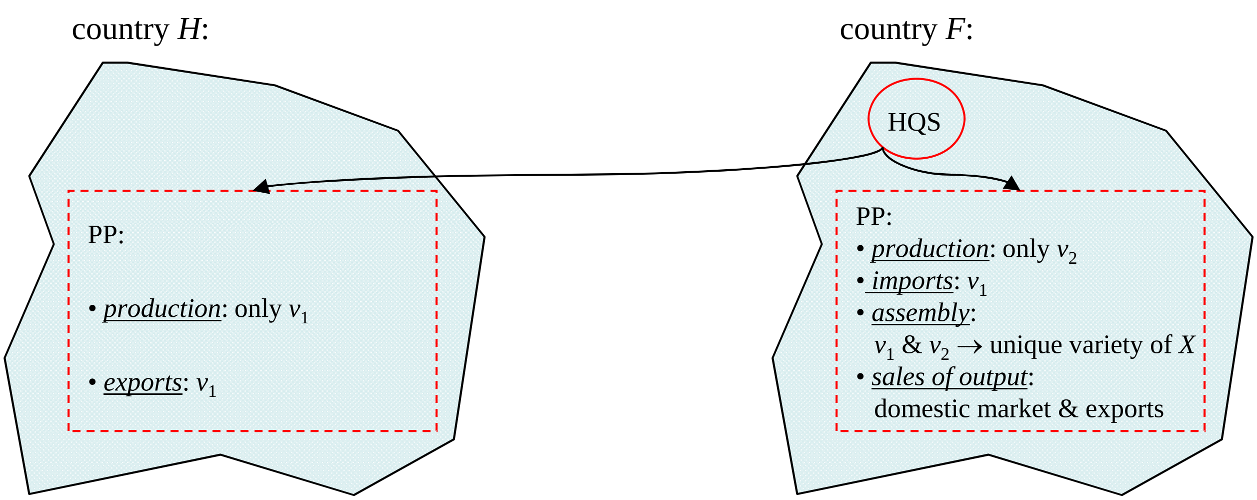


chart 2: Multinational firms with headquarters in country *F*:



Notice: HQS ≡ headquarter services; PP ≡ production plant

Figure 2: Comparative steady state results

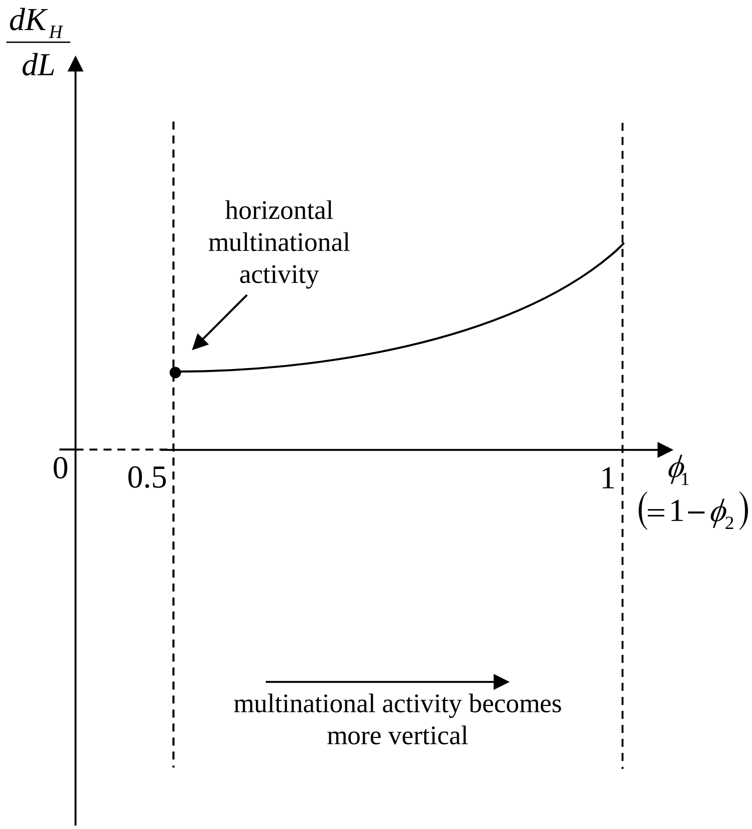


chart a) Reaction of the home country's capital stock K_H to the country–wide shock to labor productivity.

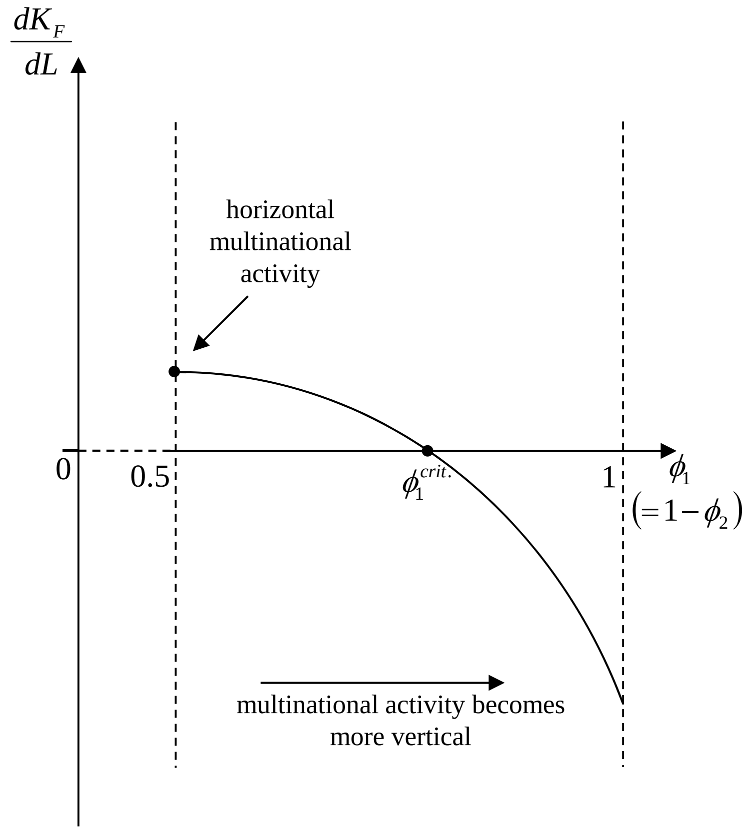


chart b) Reaction of the foreign country's capital stock K_F to the country–wide shock to labor productivity.

Notice that domestic and foreign capital expenditures are substitutes if $\phi_1 > \phi_1^{crit.}$.

TABLE 1: Descriptive statistics

	total sample	non–manufacturing sectors	manufacturing sectors
domestic investment (*DI*)			
mean	0.165	0.158	0.169
standard deviation	0.188	0.158	0.202
minimum	0	0.023	0
maximum	3	1.412	3
foreign investment (*FI*)			
mean	0.089	0.055	0.109
standard deviation	0.194	0.085	0.233
minimum	0	0	0
maximum	2.036	0.592	2.036
relative wage ($w_{par.}/w_{aff.}$)			
mean	1.761	1.523	1.899
standard deviation	0.622	0.534	0.629
minimum	0.815	0.826	0.815
maximum	4.452	3.484	4.452
relative labor share ($LS_{par.}/LS_{aff.}$)			
mean	1.347	1.170	1.449
standard deviation	0.625	0.356	0.718
minimum	0	0.526	0
maximum	4.985	3.349	4.985
observations	588	228	360

See table A1 for the classification of non–manufacturing sectors and manufacturing sectors. *DI* is defined as domestic capital expenditures of US parent companies as part of total value added of US parent companies; *FI* is defined as foreign capital expenditures of US parent companies as part of total value added of US parent companies; $w_{par.}/w_{aff.}$ is defined as the average wage at US parent companies, divided by the average wage at US affiliate firms; $LS_{par.}/LS_{aff.}$ is defined as total labor costs as part of total value added of US parent companies, divided by total labor costs as part of total value added of US affiliate firms. Subscript "par." denotes the US parent company, subscript "aff." denotes the US affiliate firm.

TABLE 2: Empirical results

	total sample			non–manufacturing sectors			manufacturing sectors		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	0.149	0.135	0.071	0.089	0.080	0.210	0.161	0.158	0.072
	(0.020)***	(0.048)***	(0.034)**	(0.038)**	(0.053)	(0.053)***	(0.013)***	(0.029)***	(0.037)*
FI	0.325	0.846	0.498	1.176	2.159	0.524	0.182	0.592	0.256
	(0.204)	(0.336)**	(0.282)*	(0.465)**	(0.193)***	(0.553)	(0.078)**	(0.101)***	(0.197)
$w_{par.}/w_{aff.}$		0.004			0.003			-0.002	
		(0.022)			(0.193)			(0.016)	
$LS_{par.}/LS_{aff.}$			0.060			-0.091			0.069
			(0.017)***			(0.043)**			(0.019)***
$FI \times (w_{par.}/w_{aff.})$		-0.242			-0.545			-0.185	
		(0.083)***			(0.085)***			(0.030)***	
$FI \times (LS_{par.}/LS_{aff.})$			-0.067			0.319			-0.034
			(0.041)			(0.112)***			(0.047)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R–squared	0.187	0.248	0.229	0.345	0.394	0.379	0.224	0.304	0.331
Observations	588	588	588	228	228	228	360	360	360

The dependent variable is *DI* (Domestic Investments). *FI* = foreign investments; $w_{par.}/w_{aff.}$ = relative wage; $LS_{par.}/LS_{aff.}$ = relative labor share. Robust standard errors, clustered at the sector level, are reported in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. All regressions include year and sector dummy variables.

Table A1: Sectors included and averages of variables

NAICS 2002 code	**Industry**	**Domestic Investment (*DI*)**	**Foreign Investment (*FI*)**	**Relative Wage ($w_{par.}/w_{aff.}$)**	**Relative Labor Share ($LS_{par.}/LS_{aff.}$)**
11	Agriculture, forestry, fishing, and hunting	0.141	0.123	3.063	1.157
22	Utilities	0.402	0.051	2.435	1.600
23	Construction	0.057	0.013	1.390	1.110
311	Food	0.122	0.056	1.684	1.135
312	Beverages and tobacco products	0.122	0.047	2.984	2.532
313–316	Textiles, apparel, and leather products	0.080	0.037	2.513	1.062
321	Wood products	0.123	0.073	1.195	1.107
322	Paper	0.115	0.053	1.761	1.212
323	Printing and related support activities	0.077	0.014	1.821	0.971
324	Petroleum and coal products	0.225	0.029	1.150	3.978
3251	Basic chemicals	0.194	0.128	1.547	1.417
3252	Resins and synthetic rubber, fibers, and filaments	0.162	0.072	1.466	1.169
3254	Pharmaceuticals and medicines	0.118	0.045	1.909	1.571
3256	Soap, cleaning compounds, and toilet preparations	0.092	0.074	2.184	1.171
3259	Other Chemicals	0.107	0.093	1.456	1.271
326	Plastics and rubber products	0.110	0.060	1.649	1.213
327	Nonmetallic mineral products	0.189	0.147	1.563	1.394
331	Primary metals	0.154	0.067	1.839	1.357
332	Fabricated metal products	0.077	0.042	1.574	1.116
3331	Agriculture, construction, and mining machinery	0.158	0.039	1.845	1.270
3332	Industrial machinery	0.124	0.021	1.266	1.130
3339	Other machinery	0.118	0.039	1.671	1.181
3341	Computers and peripheral equipment	0.158	0.059	2.696	2.151
3342	Communications equipment	0.143	0.027	2.927	1.201
3344	Semiconductors and other electronic components	0.236	0.136	3.822	1.418
3345	Navigational, measuring, and other instruments	0.072	0.015	1.476	1.243
3346	Magnetic and optical media	0.480	0.405	1.856	1.070
335	Electrical equipment, appliances, and components	0.113	0.049	2.377	1.151
3361–3363	Motor vehicles, bodies and trailers, and parts	0.611	0.137	1.829	1.172
3364–3369	Other Transportation equipment	0.101	0.003	1.684	1.153
337	Furniture and related products	0.069	0.015	1.579	0.972
339	Miscellaneous manufacturing	0.107	0.059	1.654	1.280
42	Wholesale trade	0.203	0.061	1.133	1.524

44–45	Retail trade	0.130	0.020	1.391	1.283
48–49	Transportation and warehousing	0.181	0.019	1.854	1.211
51	Information	0.233	0.023	1.350	0.866
52	Finance (except depository institutions) and insurance	0.152	0.040	1.202	1.086
53	Real estate and rental and leasing	0.568	0.344	1.193	2.040
5413	Architectural, engineering, and related services	0.045	0.022	1.257	1.128
5415	Computer systems design and related services	0.112	0.042	1.369	1.024
5416	Management, scientific, and technical consulting	0.044	0.035	1.054	1.038
5418	Advertising and related services	0.051	0.032	1.563	1.047
5419	Other Professional, scientific, and technical services	0.051	0.015	1.603	0.858
56	Administration, support, and waste management	0.075	0.014	1.325	0.914
62	Health care and social assistance	0.090	0.005	1.556	1.071
72	Accommodation and food services	0.140	0.071	1.648	1.068
81	Miscellaneous services	0.168	0.063	1.036	1.042

Numbers are averages over the period 1999–2010. Non–manufacturing sectors: NAICS codes 11, 22, 23, 42–81; manufacturing sectors: all other NAICS codes. *DI* = domestic capital expenditures of US parent companies as part of total value added of US parent companies; *FI* = foreign capital expenditures of US parent companies as part of total value added of US parent companies; $w_{par.}/w_{aff.}$ = average wage at US parent companies, divided by the average wage at US affiliate firms; $LS_{par.}/LS_{aff.}$ = total labor costs as part of total value added of US parent companies, divided by total labor costs as part of total value added of US affiliate firms.