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Estimating Models of Complex FDI: Are There Third-Country Effects?

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Abstract

The recent general equilibrium theory of trade and multinationals emphasizes the importance of third countries and the complex integration strategies of multinationals. Little has been done to test this theory empirically. This paper attempts to rectify this situation by considering not only bilateral determinants, but also spatially weighted third-country determinants of foreign direct investment (FDI). Since the dependency among host markets is particularly related to multinationals' trade between them, we use trade costs (distances) as spatial weights. Using panel data on U.S. industries and host countries observed over the 1989-1999 period, we estimate a "complex FDI" version of the knowledge-capital model of U.S. outward FDI by various recently developed spatial panel data generalized moments (GM) estimators. We find that third-country effects are significant, lending support to the existence of various modes of complex FDI.

Key words: Mutlinational firms; Complex FDI; Panel econometrics; Spatial econometrics; Generalized moments (GM) estimators
JEL classification: C33; F14; F15

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1 Introduction

Foreign direct investment is one of the most dynamic phenomena in the recent wave of globalization. The World Investment Report and the United Nations' World Trade Data Base suggest that during the last decade worldwide outward foreign direct investment (FDI) stocks rose almost 1.5 times faster than exports, even faster than exports of intermediate goods. For the last two decades, the theory of trade and multinational firms has paid attention to this phenomenon, in particular to the organization of firms across international borders. Early stages of this theory distinguish between two modes of multinational enterprises (MNEs). Vertical MNEs engage in trade and seek to exploit international factor price differentials. They locate their headquarters in the skilled labor-abundant parent country and engage in unskilled labor-intensive production in an unskilled labor-abundant host. This type of MNEs serves the parent market via foreign affiliate exports (Helpman, 1984, Helpman and Krugman, 1985). Horizontal MNEs seek to save on trade costs by serving markets locally rather than trading. This results in higher fixed investment costs than those incurred by exporting national firms (Markusen, 1984, Markusen and Venables, 2000).

The recent literature has considered three important extensions. First, both modes of MNE entry have been merged in the "knowledge-capital" model of multinationals (Carr, Markusen and Maskus, 2001, Markusen, 2002). Depending on factor endowments, as well as on trade and investment impediments, the equilibrium configuration of horizontal and vertical MNEs and of national firms is endogenously determined. Second, the role of hybrid or "complex" MNEs, which are neither purely horizontal nor purely vertical, has been emphasized by Ekholm, Forslid and Markusen (2003), Grossman, Helpman and Szeidl (2003), Yeaple (2003) and Egger, Larch and Pfaffermayr (2004). Third, the interest in more complex integration strategies has initiated a departure from the two-country case, putting emphasis on the role of (1) endowments and (2) trade and investment costs in the rest of the world.[1]

[1]Note that Yeaple (2002), Ekholm et al. (2003), Grossman et al. (2003) and Egger et al. (2004) set-up

Existing econometric work on the determinants of foreign affiliate sales and FDI seems to ignore theoretical insights into the role of third countries (see Brainard, 1997, Carr et al., 2001, Markusen and Maskus, 2002, Blonigen, Davies and Head, 2003, and Egger and Pfaffermayr, 2004). There are exceptions, however. Blonigen, Davies, Waddell, and Naughton (2004) consider aggregate U.S. outward FDI to developed economies at the country-level using pooled OLS in a spatial maximum likelihood setting. They find a negative coefficient for the spatially lagged FDI variable. Coughlin and Segev (2000) apply spatial maximum likelihood estimation to U.S. FDI across Chinese provinces. They identify a positive endogenous spatial lag of FDI. Head, Ries, and Swenson (1995) pursue a conditional logit approach in their analysis of Japanese foreign affiliates in U.S. states. Their findings point to agglomeration effects between adjacent states.

Third-country effects should be important since the average country pair is relatively small as compared to the rest of the world. This is true even when we consider a large parent's outward FDI. One can show that under complex FDI, the strength of third-country effects depends on a host country's relative remoteness from third markets. Complex multinationals operate plants abroad to serve the domestic market more cheaply, or produce locally to save on trade costs. They also engage in trade (or even FDI) with third markets. Hence, third markets affect bilateral FDI due to their weight in world-wide demand (size-related) or supply (production cost-related). They affect the bilateral environment due to their general equilibrium effects on product and factor prices. From an econometric point of view, third-country effects are important, since their omission may lead to biased parameter estimates of the determinants of bilateral FDI. It is our aim to provide insights into the effect of this omission bias on *bilateral* effects and to put forward estimates of the relative magnitude of *third-country* effects.

This paper focuses on bilateral U.S. outward FDI stocks and foreign affiliate sales

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three-country models of trade and "complex" MNEs. Helpman, Melitz and Yeaple (2004), on the other hand, consider a multi-country, multi-sector general equilibrium model of national firms and horizontal MNEs. They study the impact of firm heterogeneity and other determinants on U.S. exports and foreign affiliate sales.

at the industry level. The sample covers up to 51 host countries over the period 1989-1999. We allow for two types of spatial interaction: (i) spatially lagged explanatory variables that are motivated by a three-factor knowledge-capital model (reflecting, e.g., third-country size and relative factor endowment effects on bilateral FDI); and (ii) spatial autoregressive errors to control for regional interdependencies of stochastic shocks between the host countries. Panel data estimation is recommended, since cross-section estimates are likely to suffer from omitted variables bias caused by disregarding country specific heterogeneity effects (see Baltagi, 2005, for a general discussion and Blonigen and Davies, 2004, and Egger and Pfaffermayr, 2004, for evidence in the context of FDI). Our estimation results illustrate that third-country effects are important and lend support to the presence of complex FDI.

2 Theoretical background

To motivate our empirical approach, we focus on a model with two sectors, three factors, and three countries. The three factors are physical capital, skilled labor (or human capital), and unskilled labor. Firms in the homogeneous sector are perfectly competitive while firms in the differentiated sector engage in monopolistic competition. Headquarters of MNEs serve their affiliates with both visible physical capital (FDI) and invisible human capital (see Egger and Pfaffermayr, 2004). Production of differentiated varieties uses all three factors whereas the production of homogeneous goods relies only on unskilled labor. This model deals with empirical evidence on the role of both types of capital for bilateral FDI. It avoids knife-edge conditions so that national and multinational firms may coexist (see Baldwin and Ottaviano, 2001, or Helpman et al., 2004, for alternative approaches). Further details about this model are described in Appendix 1.

The textbook knowledge-capital model of multinational enterprises (Markusen, 2002) is based on a world of two factors and two countries. Besides national exporting firms, two types of multinationals can endogenously arise. Horizontal MNEs serve consumers in both markets locally. Instead of incurring costs associated with goods trade, these firms set up a production facility both at home and abroad. This comes at higher fixed costs when compared to national exporting firms. Accordingly, these firms are more likely to come into existence if markets are large (enabling the exploitation of economies of scale at the firm level), plant set-up costs are low, and trade costs are high (Markusen, 1984, Markusen and Venables, 2000). Therefore, horizontal MNE activity and goods trade are substitutes (Egger and Pfaffermayr, 2004). In contrast, vertical MNEs are characterized by the complete unbundling of headquarters' services (in a skilled labor abundant country) and production (in an unskilled labor abundant one, where variable costs are low). In this way, they save on fixed (domestic) plant set-up costs. Similar to national exporters, vertical MNEs engage in goods trade. They are more likely to come into existence if the parent-to-host country skilled-to-unskilled labor (capital-to-unskilled labor) endowment ratio is high, and both trade costs and foreign fixed plant set-up costs are low (Helpman, 1984, Markusen, 2002). As a consequence, vertical MNE activity and goods trade are complementary.

With more than two countries, complex modes of MNE organization arise. In such a setting, bilateral FDI not only depends on the bilateral determinants but also on the characteristics of the third market (indexed by j). We focus on a physical capital and skilled labor abundant parent country's FDI to a host economy i. In our case, the parent country is the U.S. and has the subscript d. The host economies taken together are relatively large, but relatively unskilled labor abundant as compared to the home country. In a three-country setting, bilateral FDI not only depends on the bilateral determinants but also on the characteristics of the third market j. To keep the model as simple as possible, we only consider MNEs with headquarters in d. To study the relevance of third countries for bilateral FDI, we confine our analysis to four types of "complex" FDI, which are introduced one at a time in order to isolate their determinants. h-type MNEs may be considered as more closely related to horizontal FDI, while the v-type MNEs are associated with vertical FDI. The labelling for the four types of MNEs of interest is as follows: we refer to the two complex h-type MNEs as *horizontal* (plants in d and i, with exports from d to j) and *export-platform* FDI (plants in d and i, with exports from i to

j), respectively. The two complex v-type MNEs are labelled *vertical* (plants in i and j with exports from i to d) and *complex vertical* MNEs (plants in i and j with exports from j to d), respectively.

Table 1 summarizes the predicted bilateral and third-country effects of changes in the main determinants of bilateral complex FDI. These include bilateral size, similarity in size, and the relative endowments of physical capital (K), skilled labor (H), and unskilled labor (L). The changes are kept small to ensure that the underlying plant configurations do not change. The predictions are derived from numerical simulations of the model outlined in Appendix 2.

> Table 1 - Summary of the theoretical hypotheses <

The bilateral determinants of complex horizontal and vertical FDI are similar to their simple counterparts in a bilateral three-factor two-country knowledge capital model (see Egger and Pfaffermayr, 2004). Specifically, bilateral FDI increases with bilateral total size measured in terms of GDP, the parent-to-host capital endowment ratio ($k_i = K_d/K_i$) and the parent-to-host skilled labor endowment ratio ($h_i = H_d/H_i$). However, it decreases with the unskilled labor endowment ratio ($l_i = L_d/L_i$). The corresponding impact of similarity in country size is less clear-cut. Export-platform FDI increases with similarity, while horizontal and complex vertical FDI increases with the size of d relative to i. However, vertical FDI decreases with the d-to-i size ratio. Hence, the sign of the impact of bilateral variables on export-platform (complex vertical) FDI is identical to *simple* horizontal (vertical) FDI. Two interaction terms are potentially important. The first term is the product of log differences in relative factor endowments and log transport costs. It accounts for the fact that an increase in transportation costs leads to more h-type FDI and less v-type FDI. The importance of h-type FDI relative to v-type FDI is determined by differences in relative factor endowments. The second interaction term is between the d-to-i capital endowment ratio and bilateral size. This captures the observation that d's capital abundance is more in favor of bilateral FDI at a larger bilateral size.[2] Carr et al.

[2]The pro-competitive effect can be derived from oligopolistic models of trade and MNEs as outlined

(2001) support a similar effect and argue that FDI is only positively related to bilateral country size if it is horizontal, that is, if differences in relative factor endowments are small.[3]

Regarding third-country effects, there is a trade-off between a *demand effect* and a *supply effect*. The demand effect means that an increase in country j's size (measured in terms of GDP) enhances its local demand and simultaneously changes its attractiveness relative to market i for d-based investors. The supply effect is driven by changes in country j's factor endowments relative to country i. It accounts for the possible partial reallocation of multinational production to j, and also for world-wide changes due to the increased supply of j-based exporting firms. However, the relative size of these demand and supply effects and the overall outcome of changing third-country determinants on bilateral FDI from d to i depends upon the active mode of complex MNEs.

Table 1 suggests the following conclusions:

First, any type of complex bilateral FDI from d to i unambiguously increases with the third country's market size (i.e., the combined size of d plus j at a given combined size of d and i). The reason is that more income in one of the markets increases the revenues so that MNEs can more easily cover fixed costs, i.e., plant set-up costs.[4]

Second, complex horizontal bilateral FDI from d to i increases with the similarity of country size of d and j, whereas complex vertical FDI increases with relative (d to j) size rather than with similarity (the respective sign in Table 1 is positive as long as d is smaller than j, but negative otherwise). The mechanics behind this effect are basically the same as for simple h-type and v-type FDI in a two-country setting (see Carr et al., 2001, for a two-factor setting and Egger and Pfaffermayr, 2004, for inference in a three-factor model).

Third, the impact of third-country (d-to-j) relative factor endowments exhibits a

by Markusen (2002). There, the increase in market size works in favor of MNEs due to economies of scale.

[3]Blonigen et al. (2003) and Carr et al. (2003) debate the use of simple factor endowment differences versus absolute differences. Our approach uses simple differences throughout.

[4]This size effect can turn negative if an increase in the size of third countries involves a reallocation of plants from i to j.

rather diverse pattern, depending on the form of complex FDI. However, for export-platform FDI only, all third-country effects exhibit the same sign as their bilateral counterparts. In case of complex vertical MNEs, bilateral FDI from d to i declines with $k_j = K_d/K_j$ due to j's relative *production cost disadvantage* in the differentiated goods sector.[5] In the case of horizontal FDI, this decline will be due to a *relative demand reduction.* For export-platform and vertical MNEs, the relative production cost advantage of i resulting from an increase in k_j exerts a positive impact on bilateral FDI. An increase in $h_j = H_d/H_j$ lowers firm set-up costs in d and in particular that of running a multinational network. However, at given k_j, exporting firms are also stimulated, since their set-up as well as their production also gets cheaper.[6] This crowding-out effect dominates with v-type MNEs but not with h-type MNEs. The reason is that the former's whole production takes place abroad and is discouraged by the domestic cost savings effect. In contrast, h-type MNEs also produce at home so that they take advantage of both lower fixed costs and the production cost savings effect. Lastly, an increase in $l_j = L_d/L_j$, e.g., through a reduction of L_j, increases production costs in j relative to i, but lowers total income of j. In this case, vertical and horizontal MNEs are negatively affected, while the impact on export-platform and complex vertical MNEs turns out to be positive. The reason is the presence of trade costs. Export-platform firms' trade is less affected by the income reduction in country j than horizontal firms' trade, since the latter export from the larger country. See also Anderson and van Wincoop (2003) for similar effects in a model with exporting firms only.

In summary, we expect the same parameter signs for the bilateral (d-to-i) and the third-country (d-to-j) size and factor-endowment variables only under the export-platform FDI in i.[7] However, for vertical and complex vertical FDI, a different pattern emerges. It can be shown that the third-country effects are due to MNE trade from a host-country

[5]Note that K is also used in differentiated goods production.

[6]Note that H serves also the production of differentiated goods.

[7]Similar effects would be obtained with a more direct link between markets through vertical integration of MNEs. For instance, in Grossman et al. (2003), each affiliate produces an intermediate good. In such a model, the complementarity among host markets arises from intra-firm trade in intermediates.

with the third country. Third-country effects are more important the lower the trade costs and the smaller the distance between markets i and j. This motivates the use of distance as the spatial weighting matrix in the empirical analysis below. Note that the expected signs of the bilateral and third-country effects are the same for a country's bilateral outbound foreign affiliate sales as they are for FDI.

3 Econometric approach

For the empirical analysis, we set up a bilateral specification of the three-factor knowledge capital model, but augmented by two types of spatial correlation to account for third-country effects. We introduce spatially weighted exogenous variables to capture third-country effects as illustrated by the hypotheses in Table 1 and we allow for spatial autocorrelation in the error term. The latter accounts for the transmission of shocks across host countries.

Let F_{it} denote the log of the U.S. outward FDI stock held in the country-industry-pair (i) at year (t) or the corresponding foreign affiliate sales (FAS),[8] where $i = 1, ..., N_t$, and $t = 1, .., T$. In our case, T is 11 years (1989-1999) and N_t is the number of country-industry-pairs observed at year t. In fact, N_t varies from a minimum of 331 country-industry-pairs in 1989 for FDI to a maximum of 397 country-industry-pairs in 1997. The total number of observations is $n = \sum_{t=1}^{T} N_t = 4022$ for FDI (3176 for FAS) based upon $N = 480$ (474) unique country-industry pairs spanning 51 host countries and 11 manufacturing and non-manufacturing industries.[9] The variables used in our model include $G_{it} = \ln(GDP_{US,t} + GDP_{it})$, which measures absolute bilateral country size with the US subscript indicating the parent country. A similarity index of country size was proposed by Helpman and Krugman (1985) and Helpman (1987) for bilateral trade equations. This is given by $S_{it} = (1 - s_{US,t}^2 - s_{it}^2)$ with $s_{US,t} = GDP_{US,t}/(GDP_{US,t} + GDP_{it})$ denoting the

[8] FDI stocks have been criticized because they are historical cost positions measured at their book value. They reflect prices of various years rather than constant or current dollar values. As an alternative, we also run our regressions for foreign affiliate sales.

[9] A few values of FDI or affilates sales are zero. In this case F_{it} is a missing value.

share of the U.S. and $s_{it} = GDP_{it}/(GDP_{US,t} + GDP_{it})$ denoting the share of the host country i in bilateral GDP. k_{it} is the log of the U.S.-to-host capital stock ratio, h_{it} is the log of the U.S.-to-host skilled labor endowment ratio, while l_{it} is the log of the corresponding unskilled labor endowment ratio. In order to disentangle the effects on horizontal and vertical FDI, we include the interaction terms introduced in the previous section: (i) Γ_{it} is equal to G_{it} times k_{it}, and (ii) Θ_{it} is the product of log bilateral distance between the U.S. capital and that of the host countries and $k_{it} - l_{it}$. Finally, we include an indicator of host country investment risk R_{it}. Such a political and investment climate variable has been found important in the International Finance literature. All explanatory variables are assumed to be exogenous. Appendix 4 provides details on the countries and industries studied in our sample of U.S. bilateral outward FDI stocks as well as the descriptive statistics.

The basic bilateral three-factor knowledge-capital model in vector form is given as follows (Model 1):

$$\mathbf{F}_t = \beta_0 + \beta_1\mathbf{G}_t + \beta_2\mathbf{S}_t + \beta_3\mathbf{k}_t + \beta_4\mathbf{h}_t + \beta_5\mathbf{l}_t + \beta_6\boldsymbol{\Gamma}_t + \beta_7\boldsymbol{\Theta}_t + \beta_8\mathbf{R}_t + \mathbf{u}_t. \qquad (1)$$

Bold letters denote matrices or vectors of dimension N_t due to the unbalancedness of the data. In all estimated models, we also include industry-time dummies to capture time-specific effects in a specific industry that are common to all host countries. Note that Model 1 ignores all types of spatial effects.

Second, we explicitly account for deterministic sources of third-country effects. These effects enter as a spatially weighted average of the regressors in Model 1, where the weights are based on distances (d_{ij}) between the capitals of host countries i and j. This generates the spatial weighting matrix $\mathbf{W}_{N_t}$ which is $N_t \times N_t$ and row-normalized with typical elements $w_{ij} = d_{ij}^{-1}/\sum_{j=1}^{N_t}(d_{ij}^{-1})$ if $i \neq j$ and $w_{ij} = 0$ if $i = j$. For the entire panel, $\mathbf{W}$ is a block-diagonal $n \times n$ matrix with blocks $\mathbf{W}_{N_t}$, where $n = \sum_{t=1}^{T} N_t$.[10]

[10] An added complication to our GM estimation is the fact that the panel is unbalanced. This requires careful econometric analysis with regard to which observation stays and which drops out from the sample. Although we dealt with the modification of the GM estimator for the unbalanced case, we did not deal

Model 2 reads:

$$\begin{aligned}\mathbf{F}_t &= \beta_0 + \beta_1\mathbf{G}_t + \beta_2\mathbf{S}_t + \beta_3\mathbf{k}_t + \beta_4\mathbf{h}_t + \beta_5\mathbf{l}_t + \beta_6\mathbf{\Gamma}_t + \beta_7\mathbf{\Theta}_t + \beta_8\mathbf{R}_t \\ &\quad +\beta_9\mathbf{W}_{N_t}\mathbf{G}_t + \beta_{10}\mathbf{W}_{N_t}\mathbf{S}_t + \beta_{11}\mathbf{W}_{N_t}\mathbf{k}_t + \beta_{12}\mathbf{W}_{N_t}\mathbf{h}_t + \beta_{13}\mathbf{W}_{N_t}\mathbf{l}_t \\ &\quad +\beta_{14}\mathbf{W}_{N_t}\mathbf{\Gamma}_t + \beta_{15}\mathbf{W}_{N_t}\mathbf{\Theta}_t + \beta_{16}\mathbf{W}_{N_t}\mathbf{R}_t + \mathbf{u}_t. \end{aligned} \tag{2}$$

Here, the data are first sorted by time (t) and second by country-industry-pairs (i) to account for spatial interaction.

Of course, the error term $\mathbf{u}_t$ is different in the two models. However, in both cases we allow for country-industry-pair effects μ_i to control for time invariant heterogeneity effects. These μ_i's may be either fixed or random. In the spatial Model 2, we consider the following error term: $\mathbf{u}_t = \rho\mathbf{W}_{N_t}\mathbf{u}_t + \varepsilon_t$ with $|\rho| < 1$, where $\varepsilon_{it} = \mu_i + \nu_{it}$. Under the random effects model, $\mu_i \sim IID\left(0, \sigma_\mu^2\right)$ and $v_{it} \sim IID\left(0, \sigma_\nu^2\right)$, with the two processes being independent of each other.[11] Of course, if $\rho = 0$ then the disturbances are not spatially correlated and will be of the type used in Model 1.

The estimation of Model 1 is a standard fixed or random effects procedure. Note that these estimators ignore all types of spatial effects. Estimation of Model 2 follows Kapoor, Kelejian and Prucha (2005) and proceeds in two steps. First, consistent estimates of the β's are obtained by running fixed effects on Model 2. The corresponding generalized residuals form the basis of the GM-estimator of Kapoor et al. (2005).[12]

Let $\mathbf{D}_t$ be the $N_t \times N$ matrix obtained from I_N by omitting the rows corresponding to industry-country-pairs not observed in year t. Here, N is the number of unique host-country industry pairs and $n = \sum_{t=1}^{T} N_t$ is the total number of observations. The one-way

with the possible endogeneity of stayers and quitters in a spatial model. This is an important issue for future research. A border problem may arise due to missing data. However, with a distance-based weighting scheme and large average distances between units, the border problem should be smaller than for contiguity-based weighting schemes. Both issues are relevant and should be considered in future research.

[11] See Kapoor et al. (2005) for details on the assumptions required to consistently estimate this model.

[12] We have also estimated the random effects model using the GM estimator based upon OLS residuals as suggested by Kapoor et al.(2005). Although the magnitudes for some estimates change, the results for the statistically significant estimates were basically the same.

unbalanced error component model is given by $\mathbf{\Delta_1}\mu + \nu$, where $\Delta_1 = (\mathbf{D}_1',\ \mathbf{D}_2', ...,\ \mathbf{D}_T')'$ is the selector matrix of dimension $n \times N$, which picks up the industry-country-pair effects. The projection matrix $\mathbf{P} = \mathbf{\Delta_1} \left(\mathbf{\Delta_1' \Delta_1}\right)^{-1} \mathbf{\Delta_1'}$ with $\mathbf{\Delta_1' \Delta_1} = \sum_{t=1}^{T} \mathbf{D}_t' \mathbf{D}_t = diag(T_i)$, where T_i is the number of periods we observe industry-country-pair i and $\mathbf{Q} = \mathbf{I}_n - \mathbf{P}$.

Letting $\overline{\mathbf{u}} = \mathbf{Wu}$, $\overline{\overline{\mathbf{u}}} = \mathbf{W}^2\mathbf{u}$, we use the following six moment conditions derived in Appendix 3 to estimate ρ, σ_ν^2 and σ_μ^2:

$$
\begin{aligned}
E((\mathbf{u}-\rho\overline{\mathbf{u}})' \mathbf{Q} (\mathbf{u}-\rho\overline{\mathbf{u}}) - \sigma_\nu^2(n-N)) &= 0, & (3)\\
E((\mathbf{u}-\rho\overline{\mathbf{u}})' \mathbf{P} (\mathbf{u}-\rho\overline{\mathbf{u}}) - n\sigma_\mu^2 - N\sigma_\nu^2) &= 0, & (4)\\
E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)' \mathbf{Q} \left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)) - \sigma_\nu^2 tr(\mathbf{W'QW}) - \sigma_\mu^2 tr(\mathbf{W'QW\Delta_1\Delta_1'}) &= 0, & (5)\\
E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)' \mathbf{P} \left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)) - \sigma_\nu^2 tr(\mathbf{W'PW}) - \sigma_\mu^2 tr(\mathbf{W'PW\Delta_1\Delta_1'}) &= 0, & (6)\\
E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)' \mathbf{Q} (\mathbf{u}-\rho\overline{\mathbf{u}})) &= 0, & (7)\\
E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)' \mathbf{P} (\mathbf{u}-\rho\overline{\mathbf{u}})) &= 0. & (8)
\end{aligned}
$$

In the second step, we transform all variables using a Cochrane-Orcutt type transformation: $\mathbf{z}_t^*(\widehat{\rho}) = \mathbf{z}_t - \widehat{\rho}\mathbf{W}_{N_t}\mathbf{z}_t$. Next we apply the GLS-transformation on $\mathbf{z}_t^*(\widehat{\rho})$: $z_{it}^{**}(\widehat{\rho}, \widehat{\theta}_i) = z_{it}^* - \widehat{\theta}_i \overline{z}_{i.}^*$, where $\widehat{\theta}_i = 1 - \sqrt{\frac{\widehat{\sigma}_\nu^2}{T_i\widehat{\sigma}_\mu^2 + \widehat{\sigma}_\nu^2}}$ and $\overline{z}_{i.}^*$ is the average of z_{it}^* over time (see Baltagi, 2005).

4 Estimation results

Table 2 summarizes our findings from the GM-estimation for FDI, and Table 3 those for foreign affiliate sales (FAS). Model 1 estimates equation (1), which includes the bilateral regressors of the three-factor knowledge-capital model but ignores any third-country impact on bilateral FDI (FAS). This model neglects the spatial correlation in the regressors and the disturbances. Next we estimate Model 2, which includes the spatially weighted averages of the regressors in Model 1 as well as spatially correlated errors. We run these regressions on both manufacturing industries (excluding "other manufacturing") and on all industries (excluding "banking").

> Tables 2-3 - Results <

Starting with Model 1, the regressions lend support to a mix of vertical and horizontal FDI and FAS in line with previous research. Note that the host-country-industry effects were statistically significant, whether they were fixed or random, emphasizing the importance of including them. Since the Hausman test rejects the random effects model, we will concentrate on describing the fixed effects estimates.[13] For most variables, the regression estimates are statistically significant at the 5% level. Bilateral size and similarity in size exert a positive impact on both bilateral FDI and FAS, supporting models of horizontal FDI. The U.S.-to-host skilled labor ratio is positively correlated with both FDI and FAS, while the U.S.-to-host unskilled labor ratio is negatively related to manufacturing FDI. However, the effect is insignificant for FDI in all industries and it is positive and significant throughout for FAS. The U.S.-to-host physical capital ratio exerts a positive impact on bilateral manufacturing FDI. This underpins the adequacy of modelling bilateral FDI in a three-factor framework. The interaction term between U.S.-to-host physical capital endowment ratios and bilateral size indicates that the positive impact of relative capital endowments on both FDI and FAS declines with bilateral market size in accordance with the vertical model of MNEs. Finally, the estimate of the interaction term between the differences in bilateral capital-unskilled-labor ratios and bilateral distance is negative for FDI but positive for FAS. In sum, the results of Model 1 support a mix of horizontal and vertical FDI, in line with the previous literature. However, the relative factor endowment variables do not yield conclusive results. The results for FDI given in Table 2 differ from those for FAS given in Table 3. This could be due to the measurement of FDI which is

[13]The Hausman test can also be interpreted as rejecting the between estimates of the model. These are essentially obtained from a cross-section regression of the data averaged over time. These results are drastically different from the fixed effects estimates. It is not only that the magnitudes of the marginal effects change, but also the signs of the point estimates. For example, the sign of the U.S.-to-host skilled labor ratio changes, as well as the sign of the interaction term between U.S.-to-host capital ratio and bilateral size. Hence, the between estimates may lead to biased results and highlight the problem of cross-section studies that cannot account for heterogeneity of host-country-industry effects.

reported at book value (see footnote 8), or the fact that FAS are classified according to the main activity of the foreign affiliate rather than the parent. This means that FDI and FAS may not be directly comparable within industries. The results are less conclusive for 'all industries' as compared to the 'manufacturing industries'. For example, factor endowment differences seem less important for FDI of service-oriented industries than for FDI of manufacturing industries.

Model 2 adds the spatially weighted averages of the regressors in Model 1 as well as spatially correlated errors to proxy for third-country effects. Once again, the host-country-industry effects were statistically significant whether they were fixed or random, but the Hausman test did not reject the random effects model.[14] The additional spatially weighted regressors were jointly significant at the 1% level in all estimated random versions of Model 2. This indicates that Model 1, which ignored these spatial effects, suffers from omitted variable bias.

Based on these tests and diagnostics, our preferred specification is given by the Generalized Moments estimates of Model 2. Our findings provide evidence in favor of U.S. complex outward FDI and FAS. There is implicit support for the co-existence of complex horizontal and complex vertical multinationals. However, our findings do not allow us to identify the dominance of a single mode of complex MNEs. Concentrating on the significant coefficients only, the linkage between host markets is somewhat more in accordance with what we referred to as *vertical* and *complex vertical* FDI. The coefficient estimates for FAS tend to support the *vertical* mode as well. However, the negative impact of total bilateral market size points to the potential importance of plant relocation. This is also in accordance with existing models of simple horizontal FDI. In our theoretical analysis, we did not consider the simple horizontal and vertical modes of FDI.

Similar conclusions apply for Model 2 as for Model 1 (see also Egger and Pfaffermayr, 2004). The third-country effects in Model 2 are difficult to compare with previous research, since only a small number of contributions explicitly considered the influences of third

[14] The fixed effects estimator in model 2 ignores the spatial correlation in the disturbances but not in the regressors.

countries on bilateral MNE activity. Blonigen, Davies, Waddell, and Naughton (2005) come closest to our approach. They estimate specifications that are likewise inspired by the modern theory of multinational firms and apply spatial econometric techniques using FDI and/or FAS data with both a cross-section and a time dimension. They focus on the estimation of a spatial lag in a gravity-type model of bilateral U.S. outbound FDI into the Organization for Economic Co-operation and Development (OECD). However, they also include a market potential variable that is defined as the spatially weighted third-market size of a given host economy's competitors. The estimation framework is a pooled time-series cross-section spatial maximum likelihood approach. Their findings point to a significantly negative third-market size effect for U.S. outbound FDI into the OECD as a whole, similar to what we find for outbound FDI and FAS of the U.S. in a broader sample of host countries. The coefficient of spatially lagged FDI is significantly positive in this setting. However, they point out that the latter two findings tend to be sensitive to the selection of OECD host countries. They do not find a significant spatial correlation of the disturbances.

> Table 4 - Robustness <

In Table 4, we assess the robustness of our findings with respect to the choice of the spatial weighting scheme. In this table, we focus on all industries. In the first block of results for FDI and FAS, we consider a spatial weighting matrix that relies on squared inverse distances, implying a faster spatial decay of third-country effects. By way of contrast, the second block of results assumes a much slower decay, associated with a spatial weighting scheme based on inverse square roots of bilateral distances. Finally, we choose a conceptually different weighting scheme based on the average magnitude of bilateral trade flows (exports plus imports) between 1980 and 1989. This period has been chosen to ensure that the weighting scheme itself is not affected by endogeneity problems. The estimated coefficient signs in Tables 2 and 3 do not change from significantly negative to positive or vice versa. With regard to FDI, the number of significant coefficients is much higher with the trade-volume-based weighting scheme in Table 4. We conclude that the results are fairly robust with respect to the chosen weighting scheme.

5 Conclusions

Recent theoretical research suggests the importance of third-country effects as determinants of bilateral MNE sales. Our numerical simulation results of a three-factor and three-country knowledge capital model suggest some testable predictions for bilateral FDI. Most importantly, bilateral FDI should be complementary with respect to exogenous bilateral and third-country determinants in the case of horizontal export-platform FDI. In particular, we find that the bilateral and third-country effects of changes in skilled and unskilled labor endowments tend to be substitutes for vertical and complex vertical FDI.

Using a panel of manufacturing and non-manufacturing industries and a large group of host countries observed over the 1989-1999 period, we estimate a bilateral three-factor knowledge-capital model that allows for spatial correlation in the independent variables and the error term. This is done using the Kapoor et al. (2005) GM approach. Our estimation results strongly underpin the importance of third-country effects. The findings emphasize the role of U.S. complex outward FDI. The linkage between host countries seems to be positively related to goods traded by multinationals and declines with bilateral trade costs among the host countries. To some extent this also provides interesting implications for economic policy. If complex FDI is prevalent, the scope of investment liberalization, training programs, and other FDI-attracting policies in developing countries is potentially limited. These policies can only be effective if a country is not too remote from large foreign consumer bases. Otherwise, the lower production costs in such countries are outweighed by high trade costs, and affiliates cannot serve as a platform for exports to third countries or to the parent economy.

6 References

Amiti, M. and K. Wakelin, 2003, Investment liberalization and international trade. Journal of International Economics 61, 101-126.

Anderson, J.E., 2000, Why do nations trade (so little)? Pacific Economic Review 5, 115-134.

Anderson, J.E. and E. van Wincoop, 2003, Gravity with gravitas: A solution to the border puzzle. American Economic Review 93, 170-192.

Anderson, J.E. and E. van Wincoop, 2004, Trade costs. Journal of Economic Literature 42, 691-751.

Baier, S.L. and J.H. Bergstrand, 2001, The growth of world trade: Tariffs, transport costs, and income similarity. Journal of International Economics 53, 1-27.

Baldwin, R.E. and G.I.P. Ottaviano, 2001, Multiproduct multinationals and reciprocal FDI dumping. Journal of International Economics 54, 429-448.

Baltagi, B.H., 2005, Econometric analysis of panel data. Wiley and Sons, Chichester.

Blonigen, B.A. and R.B. Davies, 2004, The effects of bilateral tax treaties on U.S. FDI activity. International Tax and Public Finance, forthcoming.

Blonigen, B.A., R.B. Davies, and K. Head, 2003, Estimating the knowledge-capital model of the multinational enterprise: Comment. American Economic Review 93, 980-994.

Blonigen, B.A., R.B. Davies, G.R. Waddell, and H.T. Naughton, 2004, FDI in space. NBER Working Paper no. 10939, Cambridge, MA.

Bergstrand, J.H., 1985, The gravity equation in international trade: Some microeconomic foundations and empirical evidence. Review of Economics and Statistics 67, 474-481.

Bergstrand, J.H., 1989, The generalized gravity equation, monopolistic competition, and factor-proportions theory in international trade. Review of Economics and Statistics 71, 143-153.

Brainard, L.S., 1997, An empirical assessment of the proximity-concentration trade-off between multinational sales and trade. American Economic Review 87, 520-544.

Carr, D., J.R. Markusen, and K.E. Maskus, 2001, Estimating the knowledge-capital model of the multinational enterprise. American Economic Review 91, 693-708.

Carr, D., J.R. Markusen, and K.E. Maskus, 2003, Estimating the knowledge-capital model of the multinational enterprise: Reply. American Economic Review 93, 693-708.

Coughlin, C.C. and E. Segev, 2000, Foreign direct investment in China: A spatial econometric study. The World Economy 23, 1-23.

Davies, R.B., 2005, Fragmentation of headquarter services and FDI. North American Journal of Economics and Finance, forthcoming.

Dixit, A.K. and J.E. Stiglitz, 1977, Monopolistic competition and optimum product diversity. American Economic Review 67, 297-308.

Egger, P., M. Larch, and M. Pfaffermayr, 2004, Multilateral trade and investment liberalization: Effects on welfare and GDP per capita convergence. Economics Letters 84, 133-140.

Egger, P. and M. Pfaffermayr, 2004, Distance, trade and FDI: A Hausman-Taylor SUR approach. Journal of Applied Econometrics 19, 227-246.

Ekholm, K., R. Forslid, and J.R. Markusen, 2003, Export-platform foreign direct investment. NBER Working Paper no. 9517, Cambridge, MA.

Grossman, G.M., E. Helpman, and A. Szeidl, 2003, Optimal integration strategies for the multinational firm. NBER Working Paper no. 10189, Cambridge, MA.

Head, K., J. Ries, and D. Swenson, 1995, Agglomeration benefits and location choice: Evidence from Japanese manufacturing investments in the United States. Journal of International Economics 38, 223-47.

Helpman, E., 1984, A simple theory of international trade with multinational corporations. Journal of Political Economy 92, 451-472.

Helpman, E., 1987, Imperfect competition and international trade: Evidence from fourteen industrial countries. Journal of the Japanese and International Economies 1, 62-81.

Helpman, E. and P.R. Krugman, 1985, Market structure and international trade. MIT Press, Cambridge, MA.

Helpman, E., M. Melitz, and S.R. Yeaple, 2004, Export versus FDI with heterogeneous firms. American Economic Review 94, 300-316.

Hummels, D., 2001, Toward a geography of trade costs. Unpublished manuscript, Purdue University.

Kapoor, M., H.H. Kelejian, and I.R. Prucha, 2005, Panel data models with spatially correlated error components. Journal of Econometrics, forthcoming.

Kelejian, H.H. and I.R. Prucha, 1999, A generalized moments estimator for the autoregressive parameter in a spatial model. International Economic Review 40, 509-533.

Kelejian, H.H. and I.R. Prucha, 2001, On the asymptotic distribution of the Moran I test statistic with applications. Journal of Econometrics 104, 219-257.

Leamer, E.E., 1984, Sources of international comparative advantage. MIT Press, Cambridge, MA.

Limao, N. and A.J. Venables, 2001, Infrastructure, geographical disadvantage, transport costs and trade. World Bank Economic Review 15, 451-479.

Markusen, J.R., 1984, Multinationals, multi-plant economies, and the gains from trade. Journal of International Economics 16, 205-226.

Markusen, J.R., 2002, Multinational firms and the theory of international trade. MIT Press, Cambridge, MA.

Markusen, J.R. and K.E. Maskus, 2002, Discriminating among alternative theories of the multinational enterprise. Review of International Economics 10, 694-707.

Markusen, J.R. and A.J. Venables, 2000, The theory of endowment, intraindustry and multinational trade. Journal of International Economics 52, 209-234.

Yeaple, S.R., 2003, The complex integration strategies of multinational firms and cross-country dependencies in the structure of foreign direct investment. Journal of International Economics 60, 293-314.

Appendix

1. **Model**

We assume that Dixit and Stiglitz (1977) type differentiated goods (x) and homogeneous goods (Y) are aggregated by a Cobb-Douglas function to give utility in country d

$$\begin{aligned}
U_d &= \left[F_{dd}x_{dd}^{\frac{\varepsilon-1}{\varepsilon}} + F_{id}\widetilde{x}_{id}^{\frac{\varepsilon-1}{\varepsilon}} + F_{jd}\widetilde{x}_{jd}^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}\alpha}\left[Y_{dd}+Y_{id}+Y_{jd}\right]^{1-\alpha} \\
\widetilde{x}_{id} &= x_{id}/t_{id}, \quad \widetilde{x}_{jd} = x_{jd}/t_{jd}, \quad t_{id}=t_{di}, \quad t_{jd}=t_{dj} \\
F_{dd} &= n_d + h_{di,dj} + h_{di,ij} \\
F_{id} &= n_i + v_{ij,id} \\
F_{jd} &= n_j + v_{ij,jd},
\end{aligned}$$

where iceberg trade costs are defined such that one unit consumed in country d requires firms in i to send $t_{id} > 1$ units. Access to identical technologies by national and multinational firms is assumed throughout. In section 2, we used the following labels for the four types of complex MNEs: horizontal MNEs ($h_{di,dj}$), export-platform MNEs ($h_{di,ij}$), vertical MNEs ($v_{ij,id}$), and complex vertical MNEs ($v_{ij,jd}$).[15] For ease of exposition, we used the fact that in equilibrium the quantities sold and the associated prices are identical, if both exporters and MNEs produce in country i for market j (for all i and j). Here, we ignore multinationals headquartered in countries i and j in order to isolate the third-country impact on complex FDI of d in i.[16] As noted above, we discuss each mode of complex FDI separately. In equilibrium, such configurations require a strong relative capital abundance of d as compared to the host markets (i, j). h-type and v-type firms are favored by low foreign investment costs g. Under parameter and endowment domains in which these

[15] Although we have also investigated the role of third-country effects for "simple" modes of FDI such as three-plant horizontal MNEs or one-plant vertical ones, we concentrate on the more realistic forms of "complex" FDI here.

[16] In fact, all models of trade and multinationals - including the recent ones on complex integration strategies - rule out one or the other type of FDI for similar purposes (Ekholm et al., 2003, is a good example for this, concentrating on platform FDI).

and other types of FDI may coexist (such as traditional, single-plant, vertical MNEs or three-plant, non-trading, horizontal ones), the comparative static results on the modes we focus on are masked by other general equilibrium effects.

Defining the price index of differentiated varieties in d as

$$s_d^{1-\varepsilon} = F_{dd} p_d^{1-\varepsilon} + F_{id} \left(t_{id} p_i\right)^{1-\varepsilon} + F_{jd} \left(t_{jd} p_j\right)^{1-\varepsilon},$$

utility maximization obtains demand from domestic and foreign firms

$$\begin{aligned} x_{dd} &\geq p_d^{-\varepsilon} s_d^{\varepsilon-1} \alpha E_d \quad \perp \quad p_d \geq 0 \\ x_{id} &= p_i^{-\varepsilon} t_{id}^{1-\varepsilon} s_d^{\varepsilon-1} \alpha E_d; \quad x_{jd} = p_j^{-\varepsilon} t_{jd}^{1-\varepsilon} s_d^{\varepsilon-1} \alpha E_d \\ E_d &= w_{Kd} K_d + w_{Sd} S_d + w_{Ld} L_d. \end{aligned}$$

Complementary goods prices (q) of homogeneous goods require

$$Y_{dd} + Y_{id} + Y_{jd} \geq \frac{(1-\alpha) E_d}{q_d} \quad \perp \quad q_d \geq 0.$$

For modelling convenience and in contrast to differentiated varieties, homogeneous goods are defined in consumed rather than produced quantities.

The four MNE types of interest are $h_{di,dj}$ (plants in d and i, with exports from d to j), $h_{di,ij}$ (plants in d and i, with exports from i to j, referred to as "export-platform FDI"), $v_{ij,id}$ (plants in i and j with exports from i to d), and $v_{ij,jd}$ (plants in i and j with exports from j to d). The zero profit conditions for these types of MNEs are given by:

$$\begin{aligned} \pi(h_{di,dj}) &= (p_d x_{dd} + p_i x_{ii} + p_d x_{dj})/\varepsilon - a w_{Sd} - (1+g) w_{Kd} \leq 0 \quad \perp \quad h_{di,dj} \geq 0 \\ \pi(h_{di,ij}) &= (p_d x_{dd} + p_i x_{ii} + p_i x_{ij})/\varepsilon - a w_{Sd} - (1+g) w_{Kd} \leq 0 \quad \perp \quad h_{di,ij} \geq 0 \\ \pi(v_{ij,id}) &= (p_i x_{id} + p_i x_{ii} + p_j x_{jj})/\varepsilon - a w_{Sd} - 2g w_{Kd} \leq 0 \quad \perp \quad v_{ij,id} \geq 0 \\ \pi(v_{ij,jd}) &= (p_j x_{jd} + p_i x_{ii} + p_j x_{jj})/\varepsilon - a w_{Sd} - 2g w_{Kd} \leq 0 \quad \perp \quad v_{ij,jd} \geq 0, \end{aligned}$$

where prices (p) are subscripted once, while quantities (x) of varieties are subscripted twice. The first subscript refers to the country of production while the second subscript refers to the country of consumption. If a variety is exported, its quantity includes the quantity lost due to iceberg transportation costs and the corresponding price is the mill price. Further, $a > 1$ is the fixed skilled labor requirement to run a multinational network and $g > 1$ is the capital requirement to set up a foreign plant. We have normalized the amount of skilled labor needed to run a national firm to one and similarly the fixed requirement of physical capital to set up a plant in the domestic market. Therefore, $a-1$ and $g-1$ are the additional fixed firm and plant costs of MNEs, respectively. ε denotes the elasticity of substitution associated with the Dixit and Stiglitz (1977) differentiated varieties, and w_{Sd} (w_{Kd}) is the factor reward of skilled labor (physical capital) in d. For the sake of brevity, we have made use of fixed mark-up pricing implied by monopolistic competition with a large number of varieties. In addition to MNEs, there are also national, single-plant firms that serve all foreign consumers by exports. Their zero profit condition reads

$$\pi(n_d) = p_d(x_{dd} + x_{di} + x_{dj})/\varepsilon - w_{Sd} - w_{Kd} \leq 0 \quad \perp \quad n_d \geq 0.$$

All zero-profit conditions in fact hold with complementary slackness. However, previous research has carefully investigated the parameter domains supporting one or the other form of complex MNEs (see Grossman et al., 2003 and Egger et al., 2004). For our purpose, it is sufficient to study the marginal third-country effects of the variables motivated by the three-factor model, given that one of the four types of MNEs is active in adition to the national exporting firms.[17]

There are two compelling reasons to adopt such a modelling strategy. First, in our empirical analysis we have to rely on bilateral industry-level data, where the direct analysis of a "rise or fall" of specific modes of FDI is extremely difficult.[18] It is very unlikely that a complete class of firms becomes extinct. Second, we rely on annual data over a relatively short period, which reduces the likelihood of observing a large-scale regime change.

[17]It is important to note that this is less restrictive than it seems at first glance. For instance, the differences between $\pi(h_{di,ij}) - \pi(h_{di,dj})$ and $\pi(v_{ij,jd}) - \pi(v_{ij,id})$ indicate that typically either $h_{di,ij}$ or $h_{di,dj}$ and either $v_{ij,jd}$ or $v_{ij,id}$ will exist.

[18]This is a problem even with the availability of firm level data due to limited information on affiliate activities.

Analytical solutions for this type of model can only be obtained under very restrictive assumptions on the parameter domain (see Grossman et al., 2003). We follow Markusen (2002) and undertake numerical simulations based on realistic parameter values. We hold the absolute factor endowments in countries d and i constant but consider changes in the third country factor endowments. In this way, we are able to isolate the role of third-country effects on real FDI from d to i, measured in terms of real capital invested abroad, expressed as g times the number of MNEs headquartered in d with affiliates in i.

The factor market clearing conditions for physical capital, skilled labor, and unskilled labor under fixed and internationally identical input coefficients read

$$
\begin{aligned}
K_d &\geq a_{KX}(F_{dd}x_{dd} + F_{di}x_{di} + F_{dj}x_{dj}) + \\
&\quad n_d + (1+g)(h_{di,dj} + h_{di,ij}) + 2g(v_{ij,id} + v_{ij,jd}) \\
&\perp \quad w_{Kd} \geq 0 \\
S_d &\geq a_{SX}(F_{dd}x_{dd} + F_{di}x_{di} + F_{dj}x_{dj}) + \\
&\quad n_d + a(h_{di,dj} + h_{di,ij} + v_{ij,id} + v_{ij,jd}) \\
&\perp \quad w_{Sd} \geq 0 \\
L_d &\geq a_{LX}(F_{dd}x_{dd} + F_{di}x_{di} + F_{dj}x_{dj}) + Y_{dd} + Y_{di}t_{di} + Y_{dj}t_{dj} \\
&\perp \quad w_{Ld} \geq 0.
\end{aligned}
$$

Given these assumptions on technologies, variable production costs of x in country d are $c_d = a_{KX}w_{Kd} + a_{SX}w_{Sd} + a_{LX}w_{Ld}$. Monopolistic competition in the large numbers case leads to a constant mark-up over variable production costs with prices

$$p_d \leq c_d \frac{\varepsilon}{\varepsilon - 1} \quad \perp \quad x_{dd} \geq 0.$$

2. Numerical simulation and parameterization

In the numerical assessment of the comparative statics of real FDI from d to i with respect to changes in the characteristics of country j, we assume an elasticity of substitution between varieties of $\varepsilon = 4$ (see also Markusen, 2002). We set the expenditure share for differentiated varieties at $\alpha = 0.8$. This is well in line with the share of manufacturing trade as percent of total trade according to the United Nations World Trade Database. In the baseline scenario, we set trade costs between all country pairs to the same value of 1.07 (see Baier and Bergstrand, 2001). To check for the "spatial" dependence assumed in the empirical set-up, we solve for a set of counterfactual equilibria assuming $t_{ij} = t_{ji} = 1.27$ and $t_{di} = t_{id} = t_{dj} = t_{jd} = 1.07$. The results do not critically depend on this assumption provided that exporting firms and multinationals co-exist. We make use of the nexus between geographical distance and trade costs as in the empirical analysis of gravity models in Bergstrand (1985, 1989), Hummels (2001), and Limao and Venables (2003). See the overview by Anderson (2000) and Anderson and van Wincoop (2004).[19] We set $a = 1.01$ and the use Cobb-Douglas coefficients suggested in Mankiw et al. (1992). We choose fixed input coefficients of $a_{KX} = 0.3$, $a_{SX} = 0.1$, and $a_{LX} = 0.6$. One could also change this assumption by employing a constant elasticity of scale framework. However, it would be difficult to ensure that factor intensity reversals do not arise. Our model predicts that multinationals arise in countries that are well-endowed with capital and skilled labor. Davies (2005) presents a frictionless trade model, in which multinationals use domestic and foreign skilled labor. The multinationals benefit from the similarity in skilled labor endowments, rather than the parent-to-host country skilled labor endowment ratio as in our model.

In the baseline scenario, we assume a world endowment of $\widetilde{K} = 80$, $\widetilde{S} = 30$, and $\widetilde{L} = 100$ at identical countries i and j in the initial equilibrium. To isolate the comparative statics with respect to changes in j, we fix country d's endowments at $K_d = 40$, $S_d = 15$, and $L_d = 40$, and country i's endowments at $K_i = 20$, $S_i = 7.5$, and $L_i = 30$. To investigate the role of the total size of d and j and their similarity in size, we increase country j's factor endowments from 90% to 110% of the baseline values, leaving relative factor endowments unchanged. To investigate the role of changes in third-country parent-to-host factor endowment ratios of K, S, and L, we change K_j from 90% to 110% of its

[19] Anderson and van Wincoop (2003) seem to be the first to explicitly consider the role of third countries in gravity models of trade.

baseline value, and similarly for S_j and L_j in the alternative experiments. In general terms, the model outcome seems robust to the parameter choice as long as the plant configuration and the factor intensity rankings remain unchanged. The resulting impact on real FDI from d to i is summarized in Table 1.

3. Derivation of moment conditions

Let D_t be the $N_t \times N$ matrix obtained from I_N by omitting the rows corresponding to industry-country-pairs not observed in year t. In this case, $\sum_{t=1}^{T} N_t = n$. The disturbance term is $\varepsilon = \mathbf{\Delta_1}\mu + \nu$, where $\mathbf{\Delta}_1 = \begin{pmatrix} \mathbf{D}_1' & \mathbf{D}_2' & \cdots & \mathbf{D}_T' \end{pmatrix}'$ is the selector matrix of dimension $n \times N$, which picks up the industry-country-pair effects. The projection matrix $\mathbf{P} = \mathbf{\Delta_1} (\mathbf{\Delta_1'}\mathbf{\Delta_1})^{-1} \mathbf{\Delta_1'}$ with $\mathbf{\Delta_1'}\mathbf{\Delta_1} = \sum_{t=1}^{T} \mathbf{D}_t'\mathbf{D}_t = diag(T_i)$, where T_i is the number of periods we observe industry-country-pair i. $\mathbf{Q} = \mathbf{I}_n - \mathbf{P}$, with $tr(\mathbf{P}) = N$ and $tr(\mathbf{Q}) = n - N$. Note that $\mathbf{Q}\mathbf{\Delta}_1 = 0$, which means that $\mathbf{Q}\varepsilon = \mathbf{Q}\boldsymbol{\nu}$. The first moment condition for the unbalanced case is given by

$$E(\varepsilon'\mathbf{Q}\varepsilon) = E(tr(\mathbf{Q}\varepsilon\varepsilon')) = tr(\mathbf{Q\Omega}) = \sigma_\nu^2 tr(\mathbf{Q}) = \sigma_\nu^2(n - N)$$

where $\mathbf{\Omega} = E(\varepsilon\varepsilon') = \sigma_\nu^2\mathbf{I}_n + \sigma_\mu^2\mathbf{\Delta_1}\mathbf{\Delta_1'}$ and $\mathbf{Q\Omega} = \sigma_\nu^2\mathbf{Q}$. The variance-covariance matrix $\mathbf{\Omega}$ follows from the fact that $\mu \sim IID(0, \sigma_\mu^2)$ and $\nu \sim IID(0, \sigma_\nu^2)$, and are assumed independent of each other and among themselves (see Baltagi, 2005).

Similarly, the second moment condition is given by

$$E(\varepsilon'\mathbf{P}\varepsilon) = E(tr(\mathbf{P}\varepsilon\varepsilon')) = tr(\mathbf{P\Omega}) = n\sigma_\mu^2 + N\sigma_\nu^2,$$

since $\mathbf{P\Omega} = \sigma_\nu^2\mathbf{P} + \sigma_\mu^2\mathbf{P}\mathbf{\Delta_1}\mathbf{\Delta_1'} = \sigma_\nu^2\mathbf{P} + \sigma_\mu^2\mathbf{\Delta_1}\mathbf{\Delta_1'}$ using the fact that $\mathbf{P\Delta_1} = \mathbf{\Delta_1}$. Note also that $tr(\mathbf{\Delta_1}\mathbf{\Delta_1'}) = \sum_{t=1}^{T} N_t = n$.

Define $\overline{\varepsilon} = \mathbf{W}\varepsilon$, where $\mathbf{W} = diag(\mathbf{W}_{N_t})$ with $\mathbf{W}_{N_t}$ being a row-normalized spatial weight matrix for the N_t industry-country-pairs observed in period t. Using the transformed disturbances, the third moment condition is given by

$$\begin{aligned} E(\overline{\varepsilon}'\mathbf{Q}\overline{\varepsilon}) &= E(tr(\varepsilon'\mathbf{W}'\mathbf{QW}\varepsilon)) = E(tr(\mathbf{W}'\mathbf{QW}\varepsilon\varepsilon')) \qquad (10) \\ &= tr(\mathbf{W}'\mathbf{QW\Omega}) = \sigma_\nu^2 tr(\mathbf{W}'\mathbf{QW}) + \sigma_\mu^2 tr(\mathbf{W}'\mathbf{QW}\mathbf{\Delta_1}\mathbf{\Delta_1'}). \end{aligned}$$

Note that

$$tr(\mathbf{W}'\mathbf{W}) = \sum_{t=1}^{T} tr(\mathbf{W}'_{N_t}\mathbf{W}_{N_t}), \text{ and} \tag{11}$$

$$tr(\mathbf{W}'\mathbf{P}\mathbf{W}) = tr[(\sum_{t=1}^{T}\mathbf{D}'_t\mathbf{W}_{N_t}\mathbf{W}'_{N_t}\mathbf{D}_t)diag(1/T_i)], \tag{12}$$

from which one can obtain $tr(\mathbf{W}'\mathbf{Q}\mathbf{W}) = tr(\mathbf{W}'\mathbf{W}) - tr(\mathbf{W}'\mathbf{P}\mathbf{W})$. For the balanced panel data case, as in Kapoor et al. (2005), $\mathbf{D}_t = \mathbf{I}_N$ and $\mathbf{W}_{N_t} = \mathbf{W}_N$ for every t. Therefore, $tr(\mathbf{W}'\mathbf{W}) = \mathbf{T}tr(\mathbf{W}'_N\mathbf{W}_N)$ and $tr(\mathbf{W}'\mathbf{P}\mathbf{W}) = tr(\mathbf{W}'_N\mathbf{W}_N)$, so that $tr(\mathbf{W}'\mathbf{Q}\mathbf{W}) = (T-1)tr(\mathbf{W}'_N\mathbf{W}_N)$.

Similarly,

$$tr(\mathbf{W}'\mathbf{Q}\mathbf{W}\boldsymbol{\Delta}_1\boldsymbol{\Delta}'_1) = tr(\mathbf{W}'\mathbf{W}\boldsymbol{\Delta}_1\boldsymbol{\Delta}'_1) - tr(\mathbf{W}'\mathbf{P}\mathbf{W}\boldsymbol{\Delta}_1\boldsymbol{\Delta}'_1), \tag{13}$$

with

$$tr(\boldsymbol{\Delta}'_1\mathbf{W}'\mathbf{W}\boldsymbol{\Delta}_1) = \sum_{t=1}^{T} tr(\mathbf{D}'_t\mathbf{W}'_{N_t}\mathbf{W}_{N_t}\mathbf{D}_t), \text{ and} \tag{14}$$

$$tr(\boldsymbol{\Delta}'_1\mathbf{W}'\mathbf{P}\mathbf{W}\boldsymbol{\Delta}_1) = tr\left\{\left[\sum_{t=1}^{T}(\mathbf{D}'_t\mathbf{W}_{N_t}\mathbf{D}_t)\right]\left[\sum_{t=1}^{T}(\mathbf{D}'_t\mathbf{W}'_{N_t}\mathbf{D}_t)\right]diag(1/T_i)\right\}. \tag{15}$$

The fourth moment condition is given by

$$\begin{aligned} E(\bar{\varepsilon}'\mathbf{P}\bar{\varepsilon}) &= E(tr(\mathbf{W}'\mathbf{P}\mathbf{W}\varepsilon\varepsilon')) = tr(\mathbf{W}'\mathbf{P}\mathbf{W}\boldsymbol{\Omega}) \\ &= \sigma_\mu^2 tr(\boldsymbol{\Delta}'_1\mathbf{W}'\mathbf{P}\mathbf{W}\boldsymbol{\Delta}_1) + \sigma_\nu^2 tr(\mathbf{W}'\mathbf{P}\mathbf{W}), \end{aligned} \tag{16}$$

where the latter terms were obtained in (12) and (15). The fifth moment condition is given by

$$\begin{aligned} E(\bar{\varepsilon}'\mathbf{Q}\varepsilon) &= E(tr(\mathbf{W}'\mathbf{Q}\varepsilon\varepsilon')) = \sigma_v^2 tr(\mathbf{W}'\mathbf{Q}\boldsymbol{\Omega}) = \sigma_v^2 tr(\mathbf{W}'\mathbf{Q}) \\ &= \sigma_v^2 tr(\mathbf{W}') - \sigma_v^2 tr(\mathbf{W}'\mathbf{P}) = 0, \end{aligned} \tag{17}$$

since $tr(\mathbf{W}') = 0$ and $tr(\mathbf{W}'\mathbf{P}) = \sum_{t=1}^{T} tr[(\mathbf{D}'_t\mathbf{W}'_{N_t}\mathbf{D}_t)diag(1/T_i)] = 0$.

Similarly, the sixth moment condition is given by

$$\begin{aligned} E(\overline{\varepsilon}'\mathbf{P}\varepsilon) &= E(tr(\mathbf{W}'\mathbf{P}\varepsilon\varepsilon')) = tr(\mathbf{W}'\mathbf{P}\boldsymbol{\Omega}) \\ &= \sigma_\mu^2 tr(\mathbf{W}'\mathbf{P}\boldsymbol{\Delta_1}\boldsymbol{\Delta_1'}) = \sigma_\mu^2 tr(\boldsymbol{\Delta_1'}\mathbf{W}'\boldsymbol{\Delta_1}) \\ &= \sigma_\mu^2 \sum_{t=1}^{T} tr(\mathbf{D}_t'\mathbf{W}_{N_t}'\mathbf{D}_t) = 0. \end{aligned} \tag{18}$$

Since our $\varepsilon = \mathbf{u} - \rho\overline{\mathbf{u}}$, the six moment conditions become

$$E((\mathbf{u}-\rho\overline{\mathbf{u}})'\,\mathbf{Q}\,(\mathbf{u}-\rho\overline{\mathbf{u}}) - \sigma_\nu^2(n-N)) = 0, \tag{19}$$

$$E((\mathbf{u}-\rho\overline{\mathbf{u}})'\,\mathbf{P}\,(\mathbf{u}-\rho\overline{\mathbf{u}}) - n\sigma_\mu^2 - N\sigma_\nu^2) = 0, \tag{20}$$

$$E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)'\,\mathbf{Q}\,\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)) - \sigma_\nu^2 tr(\mathbf{W}'\mathbf{Q}\mathbf{W}) - \sigma_\mu^2 tr(\mathbf{W}'\mathbf{Q}\mathbf{W}\boldsymbol{\Delta_1}\boldsymbol{\Delta_1'}) = 0, \tag{21}$$

$$E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)'\,\mathbf{P}\,\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)) - \sigma_\nu^2 tr(\mathbf{W}'\mathbf{P}\mathbf{W}) - \sigma_\mu^2 tr(\mathbf{W}'\mathbf{P}\mathbf{W}\boldsymbol{\Delta_1}\boldsymbol{\Delta_1'}) = 0, \tag{22}$$

$$E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)'\,\mathbf{Q}\,(\mathbf{u}-\rho\overline{\mathbf{u}})) = 0, \tag{23}$$

$$E(\left(\overline{\mathbf{u}}-\rho\overline{\overline{\mathbf{u}}}\right)'\,\mathbf{P}\,(\mathbf{u}-\rho\overline{\mathbf{u}})) = 0. \tag{24}$$

These can be solved for our estimates of ρ, σ_ν^2 and σ_μ^2.

4. Data and descriptive statistics

We use bilateral U.S. outward FDI stock data of manufacturing and non-manufacturing industries[20] as published by the Bureau of Economic Analysis, covering the period 1989-1999.[21] Real GDP figures at 1995 U.S. dollars and gross-fixed capital formation (investment) are available from the World Bank's World Development Indicators. We estimate a

[20]Manufacturing: Food and kindred products, Chemicals and allied products, Primary and fabricated metals, Industrial machinery and equipment, Electronic and other electric equipment, Transportation equipment, and Other manufacturing (excluded in regressions focussing on manufacturing industries only). Non-manufacturing: Petroleum, Wholesale trade, Finance (except banking), insurance, and real estate, and Services.

[21]The panel covers the following host countries: Argentina, Australia, Austria, Brazil, Canada, Chile, China, Colombia, Costa Rica, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Finland, France, Germany, Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Malaysia, Mexico, Netherlands, New Zealand, Nigeria, Norway, Panama, Peru,

country's capital stock by the perpetual inventory method as outlined in Leamer (1984). We make sure that the initial value of capital stocks is far enough in the past so that the impact of the initial value on the estimated time series is small. Choosing 1978 as the initial year, we estimate $K_{1978} = 2\sum_{t=1976}^{1980} I_t$, where I_t denotes investment in year t. Assuming a depreciation (δ) rate of 7%, it is straightforward to compute the annual capital stocks by the perpetual inventory method based on annual investment data ($K_t = (1-\delta)K_{t-1} + I_t$). A country's skilled (unskilled) labor endowment is measured by the endowment with labor times the share (one minus the share) of people with at least tertiary education. Labor and education data are from World Development Indicators. The investment risk variable is taken from International Country Risk Guide. Table A.1 summarizes the descriptive statistics.

> Table A.1 - Descriptive Statistics <

Philippines, Poland, Portugal, Russia, Singapore, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Trinidad and Tobago, Turkey, United Kingdom, and Venezuela.

Table 1 - Summary of Theoretical Hypotheses (The Impact on Complex FDI from d to i)

Explanatory variable[a)]	Mode of FDI: horizontal	export-platform	vertical	complex vertical
	Bilateral changes			
Bilateral size of d plus i	+	+	+	+
Similarity in size of d and i	+/-	+	-/+	+/-
K_d/K_i	+	+	+	+
H_d/H_i	+	+	+	+
L_d/L_i	-	-	-	-
Bilateral size of d plus i times K_d/K_i	+	+	+	-
$(K_d/L_d)/(K_i/L_i)$ times t_{di}	+	+	-	+/-
	Third-country changes[b)]			
Bilateral size of d plus j	+	+	+	+
Similarity in size of d and j	+	+	+/-	+/-
K_d/K_j	-	+	+	-
H_d/H_j	+	+	-	-
L_d/L_j	+	-	+	-
Bilateral size of d plus j times K_d/K_j	+	+	-	+
$(K_d/L_d)/(K_j/L_j)$ times t_{dj}	+	+	+/-	+

a) d is parent, i is host and j is third country. - b) Marginal effects based on reasonably low values of transport costs.

Table 2: Generalized moments estimation results for bilateral U.S. outward FDI stocks, 1989-1999

	Manufacturing								All Industries							
	Model 1: No spatial effects				Model 2: Spatial effects in regressors				Model 1: No spatial effects				Model 2: Spatial effects in regressors			
	Fixed effects assumes spatially uncorrelated residuals		Random effects assumes spatially uncorrelated residuals		Fixed effects assumes spatially uncorrelated residuals		Generalized moments assumes spatially correlated residuals		Fixed effects assumes spatially uncorrelated residuals		Random effects assumes spatially uncorrelated residuals		Fixed effects assumes spatially uncorrelated residuals		Generalized moments assumes spatially correlated residuals	
Explanatory variables	β	std	β	std	β	std	β	std	β	std	β	std	β	std	β	std
Bilateral determinants																
Bilateral size: β_1	6.72	0.60 ***	4.40	0.41 ***	6.79	0.62 ***	7.78	0.76 ***	6.07	0.46 ***	4.46	0.32 ***	6.12	0.47 ***	8.78	0.68 ***
Similarity: β_2	1.28	0.45 ***	1.13	0.25 ***	1.27	0.46 ***	1.91	0.51 ***	1.14	0.33 ***	1.34	0.18 ***	1.18	0.34 ***	2.43	0.42 ***
Rel. physical capital endowments: β_3	17.11	6.51 ***	0.95	3.29	15.92	6.66 **	10.48	6.95	6.50	4.78	-1.06	2.44	5.36	4.88	-1.24	5.84
Rel. skilled labor endowments: β_4	0.26	0.12 **	0.07	0.11	0.25	0.13 **	0.29	0.17 *	0.09	0.09	-0.03	0.08	0.07	0.10	0.11	0.16
Rel. unskilled labor endowments: β_5	-11.86	5.25 **	-3.31	2.19	-10.54	5.48 *	-7.71	5.35	3.17	3.92	-0.09	1.65	4.13	4.08	4.73	4.46
Rel. phys. capital endowments x bil. size: β_6	-0.09	0.12	0.13	0.08	-0.08	0.12	-0.04	0.14	-0.34	0.09 ***	0.09	0.06	-0.33	0.09 ***	-0.05	0.12
Rel. capital-unskilled labor endowments x distance: β_7	-1.65	0.61 ***	-0.43	0.25 *	-1.53	0.63 **	-1.01	0.61 *	0.34	0.46	-0.06	0.19	0.47	0.47	0.42	0.51
Host country investment risk: β_8	-0.01	0.01	0.00	0.01	-0.01	0.01	-0.01	0.02	-0.01	0.01	0.00	0.01	-0.01	0.01	-0.01	0.02
Spatially weighted third-country effects																
Bilateral size: β_9	-	-	-	-	0.81	0.91	-1.54	1.25	-	-	-	-	-0.25	0.71	-3.57	1.19 ***
Similarity: β_{10}	-	-	-	-	-0.09	0.55	0.32	0.76	-	-	-	-	-0.67	0.41 *	-1.33	0.69
Rel. phys. capital endowments: β_{11}	-	-	-	-	0.22	8.48	19.95	11.24 *	-	-	-	-	-4.40	6.03	8.10	9.73
Rel. skilled labor endowments: β_{12}	-	-	-	-	-0.48	0.31	-0.75	0.43 *	-	-	-	-	-0.74	0.23 ***	-1.32	0.40 ***
Rel. unskilled labor endowments: β_{13}	-	-	-	-	-3.57	4.92	-7.21	6.85	-	-	-	-	1.07	3.41	-4.85	5.81
Rel. phys. capital endowments x bil. size: β_{14}	-	-	-	-	0.13	0.26	-0.47	0.32	-	-	-	-	0.11	0.19	-0.15	0.29
Rel. capital-unskilled labor endowments x distance: β_{15}	-	-	-	-	-0.37	0.57	-0.75	0.79	-	-	-	-	0.18	0.39	-0.43	0.67
Host country investment risk: β_{16}	-	-	-	-	0.02	0.04	0.03	0.06	-	-	-	-	0.05	0.03	0.04	0.06
σ_v^2	0.36		0.36		0.36		0.35		0.34		0.34		0.34		0.33	
σ_μ^2	-		2.24		-		11.99		-		2.13		-		8.26	
ρ	-		-		-		0.32		-		-		-		0.44	
		p-value		p-value		p-value		p-value		p-value		p-value		p-value		p-value
Industry-time interaction effects	1.92	0.000	115.92	0.001	1.68	0.000	0.75	0.942	3.54	0.000	379.38	0.000	3.18	0.000	1.38	0.005
Country-industry-pair effects	52.63	0.000	6507.36	0.000	45.94	0.000	938.96	0.000	52.78	0.000	10436.8	0.000	47.02	0.000	1532.81	0.000
Joint significance of the spatially weighted exogenous variables	-	-	-	-	0.86	0.548	3.97	0.000	-	-	-	-	2.26	0.021	11.74	0.000

Note: Distance is used as spatial weight; the spatial weighting matrix has been row normalized. The number of observations for manufacturing (all) industries is 2501 (4022). The number of unique country-industry pairs is 294 (480).

a) F-Test in case of fixed effects, LM-Test in case of random effects.

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 3: Generalized moments estimation results for bilateral U.S. foreign affiliate sales, 1989-1999

	Manufacturing								All Industries							
	Model 1: No spatial effects				Model 2: Spatial effects in regressors				Model 1: No spatial effects				Model 2: Spatial effects in regressors			
	Fixed effects assumes spatially uncorrelated residuals		Random effects assumes spatially uncorrelated residuals		Fixed effects assumes spatially uncorrelated residuals		Generalized moments assumes spatially correlated residuals		Fixed effects assumes spatially uncorrelated residuals		Random effects assumes spatially uncorrelated residuals		Fixed effects assumes spatially uncorrelated residuals		Generalized moments assumes spatially correlated residuals	
Explanatory variables	β	std	β	std	β	std	β	std	β	std	β	std	β	std	β	std
Bilateral determinants																
Bilateral size: β_1	6.09	0.47 ***	3.33	0.38 ***	6.13	0.48 ***	9.52	0.90 ***	6.35	0.40 ***	3.83	0.31 ***	6.37	0.40 ***	11.40	0.81 ***
Similarity: β_2	0.66	0.36 *	0.73	0.22 ***	0.67	0.36 *	1.14	0.59 *	1.63	0.29 ***	1.36	0.16 ***	1.65	0.29 ***	3.15	0.48 ***
Rel. physical capital endowments: β_3	-6.22	4.68	0.85	2.76	-7.98	4.75 *	-9.51	7.95	-2.79	3.92	1.91	2.06	-3.24	3.98	-1.77	6.78
Rel. skilled labor endowments: β_4	0.09	0.10	-0.06	0.09	0.13	0.10	0.13	0.22	0.22	0.09 **	0.08	0.08	0.24	0.09 ***	0.51	0.20 **
Rel. unskilled labor endowments: β_5	15.28	3.89 ***	0.32	1.92	16.28	4.03 ***	15.31	6.25 **	15.05	3.38 ***	0.60	1.42	15.39	3.49 ***	13.35	5.43 **
Rel. phys. capital endowments x bil. size: β_6	-0.30	0.09 ***	-0.02	0.07	-0.27	0.09 ***	-0.16	0.16	-0.44	0.07 ***	-0.06	0.05	-0.43	0.08 ***	-0.33	0.14 **
Rel. capital-unskilled labor endowments x distance: β_7	1.64	0.46 ***	-0.01	0.22	1.72	0.47 ***	1.58	0.71 **	1.70	0.40 ***	0.00	0.16	1.72	0.41 ***	1.31	0.62 **
Host country investment risk: β_8	-0.01	0.01	0.00	0.01	-0.01	0.01	0.01	0.02	-0.02	0.01 **	-0.01	0.01	-0.02	0.01 *	-0.01	0.02
Spatially weighted third-country effects																
Bilateral size: β_9	-	-	-	-	-0.20	0.82	-8.75	1.73 ***	-	-	-	-	-0.10	0.76	-9.32	1.72 ***
Similarity: β_{10}	-	-	-	-	-0.27	0.41	-3.19	0.87 ***	-	-	-	-	-0.17	0.36	-3.55	0.81 ***
Rel. phys. capital endowments: β_{11}	-	-	-	-	5.03	4.76	24.18	9.82 **	-	-	-	-	4.25	4.24	20.18	9.29 **
Rel. skilled labor endowments: β_{12}	-	-	-	-	0.46	0.20 **	0.57	0.44	-	-	-	-	0.17	0.17	-0.17	0.39
Rel. unskilled labor endowments: β_{13}	-	-	-	-	-5.75	2.68 **	-13.29	5.71 **	-	-	-	-	-4.27	2.28 *	-12.81	5.19 **
Rel. phys. capital endowments x bil. size: β_{14}	-	-	-	-	0.02	0.15	-0.52	0.30 *	-	-	-	-	0.00	0.13	-0.39	0.28
Rel. capital-unskilled labor endowments x distance: β_{15}	-	-	-	-	-0.71	0.31 **	-1.52	0.65 **	-	-	-	-	-0.51	0.26 **	-1.40	0.59 **
Host country investment risk: β_{16}	-	-	-	-	-0.03	0.03	-0.01	0.07	-	-	-	-	-0.02	0.03	0.00	0.07
σ_v^2	0.36		0.36		0.62		0.17		0.34		0.34		0.66		0.22	
σ_μ^2	-		2.24		-		8.18		-		2.13		-		8.73	
ρ	-		-		-		0.53		-		-		-		0.57	
		p-value		p-value		p-value		p-value		p-value		p-value		p-value		p-value
Industry-time interaction effects	2.61	0.000	132.00	0.000	2.22	0.000	1.31	0.051	5.64	0.000	486.86	0.000	5.00	0.000	1.77	0.000
Country-industry-pair effects	80.59	0.000	4632.12	0.000	74.52	0.000	772.62	0.000	55.62	0.000	7001.37	0.000	51.46	0.000	1239.99	0.000
Joint significance of the spatially weighted exogenous variables	-	-	-	-	3.27	0.001	15.40	0.000	-	-	-	-	1.68	0.097	21.97	0.000

Note: Distance is used as spatial weight; the spatial weighting matrix has been row normalized. The number of observations for manufacturing (all) industries is 1930 (3176). The number of unique country-industry pairs is 272 (447).

a) F-Test in case of fixed effects, LM-Test in case of random effects.

*** significant at 1%, ** significant at 5%, *significant at 10%

Table 4: Sensitivity analysis of spatial generalized moments estimation results for bilateral U.S. outward FDI stocks and foreign affiliate sales, all industries

	Spatial weights are based on $(1/d_{ij})^2$ Fast spatial decay				Spatial weights are based on $(1/d_{ij})^{0.5}$ Slow spatial decay				Spatial weights are based on $(1/trade_{ij})$			
	FDI		FAS		FDI		FAS		FDI		FAS	
Explanatory variables	β	std	β	std	β	std	β	std	β	std	β	std
Bilateral determinants												
Bilateral size: β_1	8.78	0.68 ***	9.75	0.67 ***	9.45	0.73 ***	13.51	0.97 ***	6.05	0.44 ***	5.67	0.40 ***
Similarity: β_2	2.43	0.42 ***	2.35	0.43 ***	2.55	0.45 ***	3.82	0.58 ***	1.64	0.27 ***	1.83	0.24 ***
Rel. physical capital endowments: β_3	-1.24	5.84	-3.71	6.04	1.30	6.33	0.60	8.15	6.40	3.84 *	3.57	3.30
Rel. skilled labor endowments: β_4	0.11	0.16	0.45	0.16 ***	0.01	0.17	0.62	0.24 ***	0.04	0.10	0.22	0.10 **
Rel. unskilled labor endowments: β_5	4.73	4.46	14.89	5.00 ***	3.28	4.81	14.81	6.48 **	-3.46	2.99	2.41	2.61
Rel. phys. capital endowments x bil. size: β_6	-0.05	0.12	-0.33	0.12 ***	-0.09	0.13	-0.46	0.16 ***	-0.05	0.07	-0.17	0.06 ***
Rel. phys. capital endowments x distance: β_7	0.42	0.51	1.51	0.57 ***	0.25	0.55	1.42	0.74 *	-0.48	0.34	0.16	0.30
Host country investment risk: β_8	-0.01	0.02	-0.01	0.01	-0.01	0.02	-0.01	0.02	-0.01	0.01	0.00	0.01
Spatially weighted third-country effects												
Bilateral size: β_9	-3.57	1.19 ***	-4.45	0.68 ***	-6.17	2.89 **	-19.95	4.67 ***	-4.36	1.04 ***	-2.54	0.84 ***
Similarity: β_{10}	-1.33	0.69 *	-1.79	0.30 ***	-3.48	1.79 *	-7.07	2.27 ***	-1.70	0.55 ***	-0.21	0.46
Rel. phys. capital endowments: β_{11}	8.10	9.73	5.62	3.90	5.95	24.59	71.13	24.56 ***	15.13	5.90 ***	16.69	4.24 ***
Rel. skilled labor endowments: β_{12}	-1.32	0.40 ***	0.02	0.15	-3.22	1.00 ***	0.08	1.06	-0.44	0.27	0.13	0.20
Rel. unskilled labor endowments: β_{13}	-4.85	5.81	-4.38	1.99 **	-10.67	15.01	-46.71	14.12 ***	-12.22	4.29 ***	-9.86	2.75 ***
Rel. phys. capital endowments x bil. size: β_{14}	-0.15	0.29	-0.10	0.12	0.10	0.71	-1.19	0.72 *	-0.19	0.13	-0.29	0.10 ***
Rel. phys. capital endowments x distance: β_{15}	-0.43	0.67	-0.46	0.23 **	-0.94	1.73	-5.30	1.62 ***	-1.35	0.49 ***	-1.13	0.32 ***
Host country investment risk: β_{16}	0.04	0.06	-0.02	0.03	0.25	0.14 *	0.09	0.17	0.06	0.03 **	-0.04	0.03
σ_v^2	0.33		0.11		0.34		0.23		0.37		0.30	
σ_μ^2	8.26		8.35		9.07		9.44		9.55		9.20	
ρ	0.44		0.46		0.48		0.64		0.14		0.15	
		p-value		p-value		p-value		p-value		p-value		p-value
Industry-time interaction effects	1.38	0.005	2.03	0.000	1.26	0.035	1.66	0.000	2.65	0.000	3.75	0.000
Country-industry-pair effects	1532.8	0.000	1202.93	0.000	1559.30	0.000	1261.76	0.000	1433.79	0.000	1144.09	0.000
Joint significance of the spatially weighted exogenous variables	11.74	0.000	38.32	0.000	6.07	0.000	10.33	0.000	4.16	0.000	9.84	0.000

Note: The number of observations for FDI (FAS) is 4022 (3176). The number of unique country-industry pairs is 480 (447).

*** significant at 1%, ** significant at 5%, *significant at 10%

Table A.1: Descriptive statistics

Bilateral variables	Mean	Std	Min	Max
Bilateral stocks of outward FDI	4.95	1.92	0.35	8.60
Bilateral foreign affiliate sales (FAS)	6.29	2.18	0.00	11.05
Bilateral size	27.13	0.65	26.28	29.39
Similarity	-1.23	0.69	-3.79	-0.69
Rel. physical capital endowments	0.57	1.53	-3.07	4.47
Rel. skilled labor endowments	-0.07	0.68	-1.53	2.02
Rel. unskilled labor endowments	0.87	1.48	-3.32	3.93
Interaction rel. phys. capital endowments and bil. size	14.61	41.66	-90.31	118.14
Interaction rel. phys. capital endowments and distance	-2.53	11.33	-18.39	29.07
Host country investment risk	6.6706	1.704	2.00	11.00

All variables are expressed in logs. The number of observations is n=4022 (3176 for FAS). This is based on N=480 (474 for FAS) uinque country-industry pairs observed over T=11 periods (1989-1999). N_t is number of country-industry pairs observed in period t.