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2 authors:

Stephen G. Hall
University of Leicester

Pavlos Petroulas
BANK OF GREECE

University of Leicester

DEPARTMENT OF ECONOMICS

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Stephen G. Hall, University of Leicester, UK and Bank of Greece
Pavlos Petroulas, Bank of Greece

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Spatial Interdependencies of FDI Locations: A Lessening of the Tyranny of Distance?

Stephen G. Hall
Dept. of Economics, University of Leicester
Bank of Greece

Pavlos Petroulas[♣]
Bank of Greece

Abstract

Recent theoretical approaches stress the importance of complex integration strategies of multinationals and the interdependence between locations. Up till now little has been done to incorporate the potential cross-country dependencies into the empirical analysis of the determinants and the structure of foreign direct investment. By utilizing a panel data set that consists of real FDI stocks for 476 country pairs for the years 1994-2004 and a distance weighted spatial matrix, we find significant third country effects. Interestingly, the bilateral variables seem to be in concordance with the notion of horizontally motivated FDI while the spatial third country effects seem to comply with the notion of vertical FDI and production fragmentation. While bilateral variables seem to dominate location decisions the results confirm the existence and importance of international interdependence.

Keywords: Foreign Direct Investment, Spatial Econometrics, Panel Data
JEL Classification: F21, F23, C31, C33

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[♣] Corresponding author, email: ppetroulas@bankofgreece.gr , Special Studies Division, Economic Research Department, Bank of Greece. 21 El. Venizelos Av., Athens 102 50, Greece. tel: +30 210-3202643

Introduction

New Trade Theory and the theory of Multinational Enterprises (MNE) is spatial in its nature and, naturally, there exists a suspicion that the choice of location and the nature of Foreign Direct Investment (FDI) is not independent of the characteristics of the surrounding economies.

Traditional theoretical models of FDI have been analyzed in a two country setting which restricted the analysis of international/spatial interdependence. Empirical approaches have, by and large, mirrored theory insofar that FDI between two countries usually depends only on the two countries in question and where the influence of the 'rest of the world' is largely ignored.

The recent theoretical literature has started to analyze international interdependencies in multi-country and multi-good settings, with each new model yielding interesting insights. These models clearly highlight the complex country/market interdependence when it comes to the level and the structure of FDI as well as its implications for trade.[1]

While there is evidence that FDI in different locations may be complementary, little has been done to incorporate the potential cross-country dependencies into the empirical analyses of the determinants and structure of FDI. There are, however, some recent notable exceptions using spatial econometric approaches in order to examine FDI behaviour. Coughlin and Segev (2000) consider US FDI across Chinese provinces. They find that a region's FDI is positively correlated with FDI into neighbouring regions (a positive spatial lag), which is attributed to agglomeration economies. Two further papers, Blonigen et al. (2007) and Baltagi et al. (2007) find significant spatial relationships for US FDI, using different samples, model approximations and methodologies.

In this paper we use data on real outward FDI stocks. We have 17 countries of origin and 29 countries of destination, hence (17*28) 476 distinct country pairs, for the years 1994-2004. Our approach is somewhat similar to Baltagi et al. (2007) insofar that we model the spatial dependencies on the independent variables as well as the error structure. Using maximum likelihood estimations proposed by Elhorst (2003) as well as the generalized moments (GM) estimator of Kapoor et al. (2007), we find strong evidence of spatial dependence in the determinants of FDI. The empirical findings support the existence of interdependent FDI with both horizontal as well as vertical interactions/motivations. As in Blonigen et al., the bilateral variables do not seem, in general, to suffer from omitted variables bias due to the exclusion of third country effects.

The remainder of the paper is organized as follows: Section 2 provides a quick review of recent theoretical approaches that emphasize third country effects on the location decision of FDI. Section 3 discusses the data and the empirical approach of spatial

[1] Ekholm et al. (2007), Yeaple (2003), Grossman et al. (2006) and Markusen and Venables (2007).

interdependence while Section 4 presents the empirical model. Section 5 presents the main results and Section 6 concludes.

1 Theoretical motivation

Von Thünen (1826) showed how the tyranny of distance could be used as a tool for understanding patterns of production and how heterogeneity in production can arise from homogenous land through the existence of transport costs. Relatively more recently, it was Myrdal (1957) who raised the question of whether balanced regional development is an automatic process and what policies might be required. These questions, on regional development, were then extensively analyzed by Kaldor (1970). Kaldor's analysis was in turn given a more rigorous underpinning by Krugman (1991) in his 'core-periphery model', which pioneered a whole new class of models, under the title of "new economic geography".

The "new economic geography" models feature both forces of agglomeration as well as forces of dispersion where the relative strength of these forces is determined by trade costs. As a rule, agglomeration forces are hump-shaped with respect to trade costs and, depending on the starting point, dispersion forces may dominate, hence lessening the tyranny of distance. Nonetheless, historically, the lowering of transportation costs that accompanied technological progress has reinforced economies of agglomeration, creating specialised large industrial centres. That trend may have changed, however, with the technological progress of the last two decades lowering, not only, transportation costs but also communication costs, leading to an increased importance of dispersion forces.

Traditionally, the theory of FDI has distinguished between two forms of multinational activity. These are based on alternative reasons of why a firm might choose to locate production or other activities abroad (see, for example, Markusen [2002, pp.17-20]). *Vertical* multinationals are firms that geographically separate various stages of production. Such fragmentation of the production process is typically motivated by cost considerations arising from country differences in technologies or factor prices.[2] *Horizontal* multinationals, on the other hand, are firms that replicate most or all of the production process in several locations, motivated by the potential savings on transport and trading costs. In these models firms with headquarters in a home country produce final output in each country in order to serve the respective national market consumers.[3] These two modes of FDI have recently been successfully merged in the "*knowledge-capita*l" model, which provides reasons for both vertical as well as horizontal motivations endogenously, giving the approach a much richer structure. [4]

However, as Markusen and Venables (2007) point out, the above models of MNE's have been analyzed in two-country settings. Even though rich insights have been gained, there are inherent limitations to this two-ness that rule out many interesting

[2] For example, Helpman (1984) and Helpman and Krugman (1985) model multinational firms that maintain their headquarters in one country but manufacture output in another in order to conserve on production costs.
[3] For example, models developed by Markusen (1984), Brainard (1997) and Markusen and Venables (2000).
[4] Carr et al. (2001), Markusen (2002) and Blonigen et al. (2003).

and potentially important issues. Casual empirical observations has highlighted these limitations and stressed the need for a richer set of factors that determine the location and nature of FDI. Yeaple (2003) notes that the UN's World Investment Report (1998) identifies multinational enterprises that increasingly follow, what they term, complex integration strategies. These MNE's follow both vertical and horizontal motivations blurring the lines between traditional economic determinants. In this vein Ekholm et al. (2007) note that US affiliates in 2000 exported 36 percent of their total sales. Out of these exports, only a third was exported back to the US (vertical integration), while two thirds were exported to other countries. Also, Feinberg and Keane (2003) report that, for US affiliates in Canada, 69 percent follow some hybrid/complex form of integration strategy. These observations have spawned a new set of theoretical models that abstract from a two-country setting and allow researchers to analyze a wider variety of motivations for FDI and their potential inter-dependencies.

1.1 Theoretical Models

Spurred by these casual observations, theoretical research abstracted from the two-ness in order to obtain a richer and more realistic structure of firm organization. Yeaple (2003) studies a model with two identical "Northern" countries and a third, "Southern" country. The firms' headquarters are in one of the Northern countries and the firms need two produced inputs to assemble differentiated final goods. One component can be produced more cheaply in the North, the other in the South. All final goods consumption takes place in the North and shipping entails an "iceberg" transport cost that is a similar proportion of output for intermediate goods as for final goods. As usual the horizontal motives come from transport costs, while vertical motives come from factor price differentials.

In the analysis, emphasis is put on the conditions that must prevail in order for "complex multinationals" to arise, where a "complex multinational" produces one component in the South and the other in both Northern countries. The key to this complex integration comes from the fact that both horizontal as well as vertical FDI reduce the cost of serving markets in complementary ways. Having made a horizontal (vertical) investment and hence expanded the units sold, these firms gain proportionately more, in terms of unit cost reduction, by undertaking vertical (horizontal) foreign investment. The end result is that the optimal level of vertical (horizontal) foreign investment will depend on the level of horizontal (vertical) foreign investment. The mode of FDI in Yeaple's model depends on the initial level of transport costs. When the level of transport costs fall within an intermediate range complex integration strategies dominate other foreign investment strategies.[5]

Grossman et al. (2006), while keeping the three country setting and allowing for the separation of intermediate good consumption and assembly, take the analysis further

[5] In Yeaple's model of symmetric producers, all firms adopt the same integration strategy in equilibrium. The viability of the four different organizational forms depends on factor-price differentials, shipping costs and the fixed costs of establishing subsidiaries in the North and South. Moreover, the level of FDI in one country depends on the characteristics and policies of its neighbours, and this dependence has important implications for the structure of FDI across countries.

by departing from some restricting assumptions, in order to allow firms to face a richer array of choices. They allow for consumption of the final good in the South as well as the North. They allow for fixed costs and transport/trade costs that vary by type (intermediate good production or assembly) and, following Melitz (2003) and Helpman et al. (2004), they allow firms to be heterogeneous in terms of productivity.

The key parameters used to describe an industry are the sizes of the transport costs for intermediate and final goods, the relative size of the fixed costs for different types of subsidiaries and the share of the consumer market that resides in the South. In equilibrium, firms with different productivity levels may make different choices about their organizational form and hence the model can account for the equilibrium coexistence of a variety of integration strategies within the same industry.[6]

In a similar vein Ekholm et al. (2007) study a model with two similar Northern countries, each with a firms' headquarter, and a single Southern country.[7] Their purpose to present a simple model showing the conditions under which export-platform FDI is likely to arise and the conditions under which sales to third countries dominate the affiliate's production. Each firm produces an intermediate good in its home country but may assemble its final output in one or more plants located in any or all of the countries. They explore two different settings: one, where all trade costs are symmetric among countries, and one, where a free-trade area exists between one Northern country and the South (hence non-symmetric trade-costs between countries). In the symmetric case, they find that export-platform FDI is supported for moderately low transportation costs for the intermediate product and moderately low unit cost for production in the South. In the asymmetric case, i.e. where one Northern country is inside a free trade area with the South and the other Northern country is outside, both firms become export-platform firms with a lowering of trade costs when serving the other northern market. However, a further lowering of trade costs causes the inside firm to conduct all assembly in the South, becoming a pure export platform. In the empirical analysis they conduct, they find strong support for export-platform FDI.

Building on the export-platform setting, Markusen and Venables (2007) develop a multi-country model with two final goods where one good can be fragmented into component production and assembly and where countries differ in terms of trade costs and factor-endowments (and hence factor prices). This model generates both market-oriented and export-platform activity, occurring simultaneously but for different sets of countries. Both types emerge naturally from different combinations of factor proportions and trade costs. The division of countries into those engaging in market-oriented activity and those engaging in export-platform depends primarily on trade costs, while specialization in components or in assembly is determined primarily by factor endowments. In general, countries with a high capital to labour ratio act as parent countries while labour abundant countries act as hosts. Moreover, countries with high trade costs tend to have market-oriented investment while countries with low trade costs tend to have export-platform investment.

Apart from above mentioned insights, there are some other quite interesting results that feature in this model: First, there is a set of countries that lose from

[6] This is in keeping with the evidence reported by Hanson et al. (2001) and Feinberg and Keane (2003)
[7] Both Yeaple and Ekholm et al. assume that no consumption occurs in the South. This assumption reduces the number of considered cases by a large amount in both cases.

fragmentation. Second, many countries respond to fragmentation by specializing and trading *less* since trade in final assembled products is replaced by trade in components Third, lower trade costs increase trade volumes and specialization, and the relationship between trade costs and trade volumes is non-linear for the world as a whole even *without* vertical specialization, while fragmentation further increases trade volumes in line with the findings of Yi (2003).

The models presented briefly above, give an indication of the rich structure that may lead to spatial interdependencies in FDI location. Most of these spatial interdependencies seem to involve transport costs (that depend on distance among other things), market access issues, endowment differences and technology. In the empirical approach we will try to include these variables in order to address the spatial interdependencies of FDI locations.

2 Empirical approach

2.1 The FDI Data

In order to investigate locational/spatial interdependencies of countries' FDI, we use the real outward FDI stock from 17 countries of origin to 29 host countries for the period 1994-2004. Bilateral outward stock data exist for the EU15, the USA and Japan. Hence these countries will act as countries of origin. However, if we confined our host country sample to these countries only, we would probably introduce a bias in the spatial behaviour.[8] Take for example European investment: since the US is such a large economy a lot of FDI will be directed towards the US, which also happens to be far away, hence distance would not seem to matter. The same would be true for US investment in Europe, which is predominantly to large countries. Apart from this we would actually miss out on some very important FDI host countries for both US and Japanese investment. In order to have a richer structure in the data and to try and avoid spatial biases we include, admittedly in a somewhat arbitrary manner,[9] countries that a) are 'close' to the US or Japan and b) that are important as host countries. These countries are, predominantly, low-cost, labour abundant countries, which should give us a 'better' balance in terms of host countries that have 'horizontal' and 'vertical' motivation of FDI.

2.2 Spatial Dependence

Two problems appear generally in traditional econometrics when data have locational components in them. The first is spatial dependence between observations and the second is spatial heterogeneity in the relationships modelled.[10] The easiest way, perhaps, to understand this is by invoking Tobler's (1970) 1st law of Geography:

[8] The advantage would be that one could double-check the figures. For example, USA's outward stock to Japan should be the same as Japan's inward stock from the USA.
[9] The countries chosen do represent more than 85 percent of world outflows as well as inflows. Appendix C lists the countries in the sample.
[10] In this paper we will deal with issues of spatial dependence and spatial autocorrelation leaving issues of spatial heterogeneity unaddressed.

"Everything is related to everything else,
but near things are more related than distant things."

Location and distance are important determinants of human geography as well as economic activity. These notions have been formalized in regional science theory where spatial interaction, spatial diffusion and spatial spillovers play a central role. In our specific case, it is probably true that many factors explaining FDI cannot be put explicitly in our models. It is also probable that many of these factors are strongly spatial in nature. Take, for example, country boundaries, which are often quite arbitrary. It is very likely that two regions, one on each side of the border, have more in common than two regions within the same country that are distant. In the same spirit, countries that share borders often have many more similarities than countries that do not. These similarities can include legislative issues, bureaucratic organization, work ethics, familiar mentality concerning social interaction etc. It may also be that neighbouring countries tend to have similar structures of economic activity. These factors can cause a neighbouring country to be viewed as less risky, or preferable, to invest in. Hence, spatial effects might be picking up these potentially omitted variables which have a strong spatial element in them. We would thus expect spatial dependence if we believe that socio-demographics, economic-, regional- or any other relevant activity has a spatial dimension. This spatial dimension can turn out to be an important and informative aspect of a modelling problem.

In a model of the form $Y= a+ XB+u$ we can have spatial spillovers, i.e. some form of spatial dependence, emanating from the errors, the dependent variable or the explanatory variables. The functional relationship of the recent theoretical models concerning production fragmentation, and hence the interdependence of FDI location, imply that the spatial dependence is best captured if we model it through the explanatory variables. Lastly, if Tobler's law holds, we would also expect that there is some coexistence of attribute value similarity and locational similarity. This implies a spatial dependence emanating from the model's errors (i.e. spatial autocorrelation) which we have to take into account.[11]

2.2.1 The distance weighted spatial expansion model

This class of models where introduced by Casetti (1972, 1992). The approach allows us to ascribe different weights to observations based on their distance from a central place of origin. It is a suitable way of modelling the phenomenon that reflects a "hollowing out" or a decay of influence with distance from the central point. The distance expansion model with n spatial units and k parameters can be written as:

$$y = X\beta_0 + X\beta_1 + \varepsilon$$
$$\beta_1 = WJ\beta_0 \qquad 1.$$

Where:

[11] The modeling of a spatial dependent variable would in our case capture some form of regional agglomeration effect. While this might be of interest in itself it will not tell us anything about the modes of FDI and in what specific way, if any, international interdependence exists.

$$y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}; X = \begin{pmatrix} x_1' & 0 & \dots & 0 \\ \vdots & x_2' & \ddots & \vdots \\ \vdots & & \ddots & \vdots \\ 0 & \dots & \dots & x_n' \end{pmatrix}; \varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix} \qquad 2.$$

$$W = \begin{pmatrix} W_{x1} \otimes I_k & & \dots & 0 \\ 0 & W_{x2} \otimes I_k & \dots & \vdots \\ \vdots & \ddots & \ddots & \vdots \\ 0 & \dots & \dots & W_{xb} \otimes I_k \end{pmatrix}; J = \begin{pmatrix} I_k \\ I_k \\ \vdots \\ I_k \end{pmatrix} \qquad 3.$$

Where β_0 is a $k*1$ vector of parameters and where $W_{xn,:}$ is the relevant weighting matrix for the variables of each spatial unit. This model is straightforward to estimate using least squares in the following form:

$$y = \alpha + X\beta + XW_x\beta_x + \varepsilon \qquad 4.$$

The only remaining issue one has to posit is what kind of expansion specification should be included, since it is not necessary that all variables exhibit spatial dependence.[12]

Traditional spatial analysis is conducted on static data with one central location of origin. Dealing with dynamic data and multiple locations of origin causes us to depart somewhat from these settings. Here, we will modify our spatial expansion in such a way that our variables of interest capture not only spatial dependence but are economically intuitive as well. In order to achieve this we will estimate a model of the form $y = \alpha + X\beta + Z_x W_z \beta_z + \varepsilon$, where Z is a set of explanatory variables, highly related to X, that will hopefully capture the spatial dependence caused by production fragmentation (if it exists) and that can be interpreted in an intuitive way.

2.2.2 The spatial autoregressive error model

In the spatial errors model the disturbances exhibit spatial dependence. This is analogous to serial correlation problems in time series models and can be specified as:

$$\begin{aligned} Y_t &= X_t\beta + c + \phi_t \\ \phi_t &= \delta W\phi_t + \varepsilon \\ E(\varepsilon_t) &= 0; E(\varepsilon_t\varepsilon_t') = \sigma^2 I_N \end{aligned} \qquad 5.$$

The spatial econometric literature has shown that ordinary least squares (OLS) estimation is inappropriate for models incorporating spatial effects. In the case of spatial error autocorrelation, the OLS estimator of the response parameters remains unbiased, but it loses the efficiency property.[13] The problems of OLS estimators are

[12] Given no spatial dependence β_x should not be significantly different from zero.
[13] In the case when the specification contains a spatially lagged dependent variable, the OLS estimator of the response parameters not only loses the property of being unbiased but also is inconsistent.

commonly overcome by using maximum likelihood techniques.[14] From Elhorst (2003), we can see that a demeaned log-likelihood function incorporating spatial error autocorrelation can be written in following form:

$$-\frac{NT}{2}\ln\left(2\pi\sigma^2\right)+T\sum_{i=1}^{N}\ln\left(1-\delta\omega_i\right)-\frac{1}{2\sigma^2}\sum_{t=1}^{T}e_t'e_t \qquad 6.$$

where:

$$e_t=\left(I-\delta W\right)\left[Y_t-\overline{Y}_k-\left(X_t-\overline{X}_k\right)\beta\right] \qquad 7.$$

and where *k* can denote time, country pair, or any other variable specification one chooses to demean by.

2.2.3 The spatial autoregressive error model part II. The GM-estimator approach

Apart from the maximum likelihood techniques, recent econometric developments allow us to model spatial correlation through generalized moments.[15] The GM-estimator, which will be used as a robustness check in our estimations, is a random effects panel data estimator, able to accommodate error components that are both spatially and time-wise correlated. We follow the arguments of Kapoor et. Al (2007) who demonstrate via Monte carol work that their GMM estimator performs in a way which is almost identical to the appropriate maximum likelihood estimator while being computationally much simpler and suitable for very large data sets or models.

For the random effects model with temporal serial correlation we augment (5) in the following way

$$\varepsilon_t=(e\otimes I)\mu+v \qquad 8.$$

Where v contains the error components which vary across N and T and $\mu\sim N(0,\sigma^2{}_{\mu})\, and\, v\sim N(0,\sigma^2{}_{v})$

The GMM estimator employs a set of six moment conditions, following Kapoor et al, define

$$\begin{aligned}\overline{\phi}&=(I\otimes W)\phi\\ \overline{\overline{\phi}}&=(I\otimes W)\overline{\phi}\\ \overline{\varepsilon}&=(I\otimes W)\varepsilon\end{aligned} \qquad 9.$$

Then the six moment conditions used are

[14] See Anselin (1988) and Anselin and Hudak (1992).
[15] See Kelejian and Prucha (1998), (1999) and Kapoor et al. (2007)

$$E(\frac{1}{N(T-1)}\varepsilon' Q_0 \varepsilon) = \sigma^2{}_v \qquad 10.$$

$$E(\frac{1}{N(T-1)}\bar{\varepsilon}' Q_0 \bar{\varepsilon}) = \sigma^2{}_v \frac{1}{N} tr(W'W) \qquad 11.$$

$$E(\frac{1}{N(T-1)}\bar{\varepsilon}' Q_0 \varepsilon) = 0 \qquad 12.$$

$$\frac{1}{N}\varepsilon' Q_1 \varepsilon = \sigma^2{}_1 \qquad 13.$$

$$\frac{1}{N}\bar{\varepsilon}' Q_1 \bar{\varepsilon} = \sigma^2{}_1 \frac{1}{N} tr(W'W) \qquad 14.$$

$$\frac{1}{N}\bar{\varepsilon}' Q_1 \varepsilon = 0 \qquad 15.$$

Where $\sigma^2{}_1 = \sigma^2{}_v + T\sigma^2{}_\mu$ and Q_0 and Q_1 are as defined in Kapoor et al.

Kapoor et al propose three GMM estimators for $\delta, \sigma^2{}_v \; and \; \sigma^2{}_1$ the first estimator uses only the first three moment conditions and is really designed as a step on the way to the full GMM estimator, the second uses all six conditions and is the preferred estimator, the third uses a simpler weighting matrix and is computationally feasible for even very large N

2.3 *The Weighting Matrix*

A common practice of spatial models is to row-standardize the weight matrix. That is to normalize each of the weights in a row such that they sum to one. While it is an advantage from both a statistical and a computational standpoint, it may change the intended “economic” relationship between observations. Our multiple locations of origin implies that row standardization would distort the distance decay effect we try to capture. Instead, we give our weights an appropriate form by normalizing them through the minimum distance (min.dist) between two countries in our sample.[16]

Since our data consist of i=1 to n=17 countries of origin and for each country of origin (i) we have j=1 to k=28 countries of destination, for the time periods t=1994(1)…2004(T), our weighting matrix, following Tobler’s 1st law, takes the following form:

[16] The row normalization approach would be relevant if we thought that a country is influenced by its neighbours and the importance of each neighbour is related to its relative and not absolute distance, for which there is no apparent reason.

$$W_{ijk} = \begin{pmatrix} w_{1,2,2}=0 & w_{1,3,2} & \dots & w_{1,2,28} & 0 & \dots & \dots & 0 & \dots & 0 \\ w_{1,3,2} & 0 & \dots & w_{1,3,28} & \vdots & \dots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{1,28,2} & \dots & w_{1,28,27} & 0 & 0 & \dots & 0 & 0 & \dots & 0 \\ 0 & \dots & 0 & 0 & w_{2,1,1}=0 & \dots & w_{2,1,28} & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \dots & \vdots \\ \vdots & \vdots & \vdots & \vdots & w_{2,28,1} & \dots & w_{2,28,28}=0 & 0 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots & 0 & \dots & 0 & w_{17,1,1}=0 & \dots & w_{17,1,28} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & \dots & \dots & 0 & 0 & \dots & 0 & w_{17,28,1} & \dots & w_{17,28,28}=0 \end{pmatrix}$$

16.

Where:

$$W_{ijk} \neq 0 \forall i,j,k : i \neq j \neq k \; ; \; w_{i,j,k} = \frac{\min .\text{dist}}{dist_{j,k}} \; ; \; w_{i,j,k} \in (0.1] \text{ and } w_{i,j,k} = w_{i,k,j} \qquad 17.$$

Since:

$$W_{i,j,k}(t) = W_{i,j,k}(t+1) = \dots = W_{i,j,k}(T) \qquad 18.$$

Hence the complete weighting matrix is:

$$W = \begin{pmatrix} W_{i,j,k}(t=1994) & 0 & 0 \\ 0 & \dots & 0 \\ 0 & 0 & W_{i,j,k}(T=2004) \end{pmatrix} \qquad 19.$$

Where $W_{i,j,k}$ is a 476*476 matrix and the complete weighting matrix W is a 5236*5236 matrix.

Putting all the steps together we can express our full model as:

$$y_{i,j}^{t} = \alpha_{i,j}^{t} + X_{i,j}^{t}\beta + Z_{j,k}^{t} W_{i,j,k}^{t} \gamma + u_{i,j}^{t}$$

where :

$$u_{i,j}^{t} = \delta W_{i,j,k}^{t} u_{i,j}^{t} + \varepsilon_{i,j}^{t} \qquad 20.$$

or in the GM estimation

$$u_{i,j}^{t} = \delta W_{i,j,k}^{t} u_{i,j}^{t} + \lambda u_{i,j}^{t-1} + \varepsilon_{i,j}^{t}$$

Where (t) denotes time, (i) denotes origin, (j) denotes destination and (k) denotes destination other than (j).

3 The Empirical Model

The empirical modelling strategy uses the knowledge-capital model as a point of reference which has the advantage of including both vertical as well as horizontal long-run motivations for FDI.[17] The model is augmented by the ratio of capital stock per head as well as by spatial third country variables.[18] Our dependent variable is outward FDI stock deflated by host country producer price index. The bilateral determinants include the sum of the host and origin countries (GDP sum), which is expected to be positive and with an elasticity greater than one. An index-variable measuring how similar the countries are in terms of income (Sim. Index) is also included. The similarity index is expected to have a positive sign since it is measured as one minus the squared GDP shares of the country pair and ranges from 0 to 0.5; hence the more similar the countries are the closer the index gets to 0.5.[19]

The determinants also include measures of relative factor endowment such as capital and labor/human capital (*Cap. Ratio* and *|Skill diff|* respectively). The difference in capital is measured as the share of real capital per head of the country of origin relative to the host country. Intuitively, the larger this share, the more capital intensive the home country is and will hence make more investment. Thus we expect a positive sign in all cases. The differences in human capital is measured as the absolute difference between the average schooling years for the population above 25 for the country of origin compared to the country of destination. Here a negative sign implies that countries similar in human capital endowments, invest more in each other, and tends to support horizontal motivations.

The knowledge-capital model also includes two interaction variables. The first tries two capture asymmetries in size and human capital and is measured as the absolute value of skill difference * GDP difference (|GDPd|*|Skilld|). The second, as Carr et al. (2001) put it, tries to capture the idea that trade costs may encourage horizontal investment, which is most important when relative endowments are similar. This is measured as the interaction between host country trade cost and the square of skill differences (Tradech*skilld^2).[20]

Trade costs for each country are included (Trade cost), measured as the inverse of real openness for each country. While trade costs for the parent country is expected to have a negative sign, the sign for the host country will depend on the motivation for investing. Specifically, trade costs for the host country is expected to be positive given horizontal motivations, while it is expected to be negative given vertical motivations. Also included is measure of investment costs of the host country (Fin. Risk). This is

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[17] The capital-knowledge model, or some variation/expansion of it, has been used by a number of studies in order to estimate FDI determinants. See for example Carr et al. (2001), Markusen (2002, ch. 12), Markusen and Maskus (2002), Blonigen et al. (2003) and Blonigen and Davies (2004). However, we do not test for any model in particular, whether this concerns the horizontal, the vertical or the knowledge-capital model.

[18] See Bergstrand and Egger (forthcoming) for the motivation for including this ratio. The ratio is also used in Baltagi et al. (2007).

[19] See Baltagi et al. (2003) and (2007).

[20] Blonigen and Davies (2004) note that these interaction terms once logged, become collinear with the main control variables. They choose to drop them while we choose to keep them in a level form. Their inclusion in level form does not affect the other explanatory variables.

measured as the inverse of the financial risk index from the International Country Risk Guide and is expected to affect FDI negatively. The final bilateral variable we include is great circle distance between capitals as a proxy for distance between countries (dist) and is expected to have a negative effect on FDI.

The spatial interaction effects are for differences between the host country (j) and all other host countries $(k \neq j)$ in the sample when they are expressed as a pair relationship. Alternatively, they concern only all other $(k \neq j)$ host countries when the spatial variable is not expressed as pair relationship. Finally, the spatially interacted variables are only for a subset of above bilateral variables.[21] These include measures of market access (W GDP) measured by surrounding markets real GDP, weighted by distance. Trade costs of the distance weighted third countries (W Trade cost h.) and distance weighted factor endowment variables (W Cap. Ratio and W |Skill diff|). The spatial factor endowment variables are measured as the host country value (which takes the place of the country of origin in the bilateral part of the specification) relative to the value of all other distance weighted host countries.[22]

From previous research, we expect that horizontal motivations for FDI will tend to dominate, at least the bilateral variables.[23] However, assuming that the MNE organize themselves such that they form supply chains and fragment their production, the spatial interaction variables should be consistent with some vertical motivations of FDI. In our case this means that W Cap. Ratio and W |Skill diff| are expected to have a positive sign and W Trade cost h. a negative one. Surrounding market GDP (W GDP) is expected to, at least, not be negative, while the effect of W Sim. Index is somewhat ambiguous. Hence the full model to be estimated in log-form is:

$$
\begin{aligned}
\ln \mathrm{FDI}_{ijt} = {} & \alpha_{i,j} + \gamma_t + \beta_1 \ln \underset{(+)}{\mathrm{GDPsum}}_{\mathrm{ijt}} + \beta_2 \ln \underset{(+)}{\mathrm{Sim.Index}}_{\mathrm{ijt}} + \beta_3 \ln \underset{(+)}{\mathrm{Cap.Ratio}}_{\mathrm{ijt}} + \\
& \beta_4 \ln \underset{(+[h]/-[v])}{\mathrm{Trade\ cost h}}_{\mathrm{jt}}. + \beta_5 \ln \underset{(-)}{\mathrm{Trade\ cost o}}_{\mathrm{it}} + \beta_6 \ln \underset{(-)}{\mathrm{Fin.Risk h}}_{\mathrm{jt}} + \beta_7 \ln |\underset{(-[h]/+[v])}{\mathrm{Skill\ diff}}|_{ijt}. + \\
& \beta_8 \underset{(-)}{\mathrm{Trade ch.*skill d}}^2_{ijt} + \beta_9 \underset{(+[h]/-[v])}{|\mathrm{GDP d}|*|\mathrm{skill d}|}_{ijt} + \beta_{10} \ln \underset{(-)}{\mathrm{distance}}_{\mathrm{ij}} + c_1 \ln \underset{(+)}{W.\mathrm{GDP}}_{\mathrm{kt}} + \\
& c_2 \ln \underset{(+/-)}{W.\mathrm{Sim.Index}}_{\mathrm{jkt}} + c_3 \ln \underset{(-[v])}{W.\mathrm{Cap.Ratio}}_{\mathrm{jkt}} + c_4 \ln W \underset{(-[h]/+[v])}{|\mathrm{Skill\ diff}|}_{jkt} + c_5 \ln \underset{(-[v])}{W.\mathrm{Trade\ cost\ h}}_{\mathrm{kt}}. \\
& + u_{ijt}
\end{aligned}
$$

The coefficients (β) refer to bilateral variables while (c) refer to third-country weighted variables respectively. The term u_{ijt} varies in form depending on whether we estimate OLS or a spatial error model with ML- and GM- techniques. The latter two will have an error coefficient δ that captures the spatial autocorrelation.

---

[21] Some of the independent variables do not have a clear economic interpretation if they are included in the spatial expansion.
[22] For the factor endowment variables, the third country effects are created as follows: First, we create a distance weighted variable for all other host countries. This variable in turn is used to create a ratio or difference relative to the host country's endowment in the bilateral observation. The other variables are straight forward distance weighted observations of all other host countries. See also Appendix C.
[23] See for example Markusen and Maskus (2002) and Baltagi et al. (2007).

4 Results

Naturally, one would prefer to estimate a model with as few restrictions imposed as possible. In our case this implies a two-way fixed effects modelling. However, given most information comes from cross-sectional differences (476 country pairs) and not time (11 years), we are ambivalent to this approach, since it eliminates the information from cross-country differences. As economists we are interested in the economic determinants that drive FDI. It will thus not be an interesting economic approach, even if it is econometrically correct, to say that mostly the results depend on unobserved country characteristics.[24] Apart from the interpretation issue, our data consists of heterogeneous panels and if we estimate a fixed effect model it will bias our coefficients towards zero.[25] Given these issues we will instead use the between estimator, which captures long-term relationships, as a guide, when we restrict our model.

Table 1 presents some base results, of the spatial expansion approach, concerning the determinants of outward FDI. Model 1 is our between estimator (BE) which acts as a guide. Here we see that both GDP sum as well as the Sim.Index are positive and significant. In accordance with priors these two variables support the notion of horizontal motivations for FDI. However, for the bilateral variables host country trade costs appear to be negative and significant, lending support to vertical motivations. Distance is as expected negative and highly significant, while surprisingly the financial risk index for the host country appears positive and significant, contrary to expectations.[26] Most importantly though, all third country variables are significant. The weighted GDP of other host countries, which captures market access, is positive and significant. The weighted similarity index, capital ratio, skill differences as well as trade costs are all significant and their signs are in line with notion of production fragmentation.

------ Table 1 about here ------

Model 2 is a random effects (RE) estimation, which is a cross product of, the fixed effects (FE, Model 3) estimator and the between estimator.[27] In both Model 2 as well as 3, we have one intercept per country pair. This limits severely the time variation of our explanatory variables.[28] Focusing on the fixed effects model, we see that for the third country variables only the weighted capital ratio appears to be significant,

[24] Due to the limited time-series, when we demean the data, or estimate the dummies, there is not enough time variation left in our explanatory variables. However, the fixed do capture other omitted variables. The econometric “incorrectness” of restricting the country dummies is verified by the rejection of these restriction from F- and LR-tests. See Appendix B.

[25] See Pesaran and Smith (1995). Also, there are not enough time observations in order to obtain pooled mean group estimators.

[26] This could be due to the fact that the financial risk index is a short-term variable in itself, while in the Between estimations we capture long-term trends. When we allow for time variation in our regressions we see that the variable becomes invariantly negative.

[27] From the relevant R^2 it is obvious that most explanatory power comes from differences between countries.

[28] One indication is that our level variables, which exhibit a larger time variation, appear to be significant. This significance is curtailed when we restrict our dummy variables in Models 4 and 5 and allow more time variation in the other explanatory variables.

contrary to the results obtained from the Between estimator. Trying to allow for more variation in our data means that we need to restrict the dummy variables and set many of them to zero. This is done in Model 4 where dummies for the countries of origin as well as dummies for the host countries are included and in Model 5, where only dummies for the host countries are included. The results from Model 5 are more or less in line with the results from the between estimator, and hence Model 5 constitutes our preferred estimation.

In Model 5, the implicit assumption is the countries of origin are assumed to be homogenous. We can ask ourselves whether it is logical not to include dummies for countries of origin, which implies that outward FDI is similar irrespective of which country actually invests. With a little good will we believe it is. Firstly, we have aggregate data. Secondly, investing countries are developed, hence the motivations would be similar across them.[29] Also, the investing countries, are on, or almost on, the same technological frontier. The host countries though, differ from each other in terms of several characteristics, such as legal origin, labor market regulations, language, number of neighbours, level of development etc., and hence we should control for unobserved host country characteristics.

However, for our main purpose here, all models, some more than others, indicate significant third country effects. Focusing on our preferred model (Model 5), we see that the bilateral variables are consistent with the notion of horizontally-motivated FDI (l GDP sum, l Sim. Index >0, l |Skill diff.|<0). The third country variables, however, indicate strong spatial interdependencies. The positive and significant estimates of our weighted factor endowment variables as well as the negative significant effect of the weighted trade costs are consistent with production fragmentation. Interestingly, we see that the bilateral capital ratio becomes insignificant.[30]

The results are consistent with the following notion. If, for example, a US firm were to invest in Germany, it would be a horizontal investment (final good assembly). This investment could not only act as a base for sales both in Germany but also in the surrounding countries. The US firm would also invest in ‘cheaper’ countries close by that would serve the German affiliate with intermediate products. Conversely, if a European company was to invest in the Americas they would make a horizontal investment in the US and use that as their sales base, while they would serve their US affiliate with intermediate products from other FDI located in Canada and/or Latin America, creating in this way regional supply chains.

Finally, comparing Models 5 and 6, we can infer two things. Even if third country effects are important, the location decision of FDI is dominated by bilateral considerations; these bilateral estimations are not very prone to miss-specification.

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[29] It would be a problem if China was included as an investor form example, since China’s investment would probably concern raw materials and would hence be quite different from Germany’s or the USA’s. Concerning the ‘poorer’ investors of our sample like Greece and Portugal, we can point out that their investment is so insignificant that it does not matter whether we include them or not. Actually these ‘poorer’ countries are also responsible for the large majority of the missing data.

[30] We can see that the two interaction variables are significant in the fixed effects specification. This is due to the fact that they appear in levels and thus show a larger time variation than the logged variables. When we move away from the fixed effects specification, which allows our logged variables a ‘larger’ time variation, they tend to become insignificant.

------Table 2 about here------

------Table 2A about here------

Table 2 adds some further spatial dependence, namely spatial autocorrelation. Comparing the results of the simple spatial expansion model, estimated by OLS, with the results obtained from the SEM-model, that are obtained by maximum likelihood estimation, we see that the point estimate (δ) of our spatial error variable is significant, albeit low, for the Models 3 and 5.[31] The point estimates of our other explanatory variables seem to be robust even in the presence of significant spatial autocorrelation in the errors.[32] In Table 2A, we row normalize the weighting matrix for the errors and compare the results with those of the preferred non-normalized matrix. As expected the coefficients for the bilateral and third country variables remain qualitatively and quantitatively similar, while the results for spatial autocorrelation do not. This can be seen in (δ), where the point estimates of spatial autocorrelation are inflated and display a much larger significance, confirming the suspicion that whether we normalize our weights or not does matter.

----Table 3 About here---

Finally, as an extra robustness check, Table 3 compares the estimation of our random effects model with the GM-estimator developed by Kapoor et al. (2007). Here the changes are more pronounced when we allow the errors to be both spatially and time-wise correlated. The variable measuring surrounding market potential, W GDP, becomes significant and positive which is in line with predictions and the results obtained by the MLE. However, the variable measuring bilateral capital endowment becomes negative and significant, which is surprising. One possible explanation, considering our sample, could be that countries with lower capital per head try move closer the technological frontier through acquisition.[33] For example, Sweden's willingness to invest in the US in order to acquire technology is larger than US' willingness to invest in Sweden because it is a richer country. Another surprise is the coefficient on the variable measuring investment cost for the host countries, Fin.Risk host, which is positive. This conundrum does not, however, affect our remaining results when we drop the variable in question for a more parsimonious estimation (Table 3A). The weighted third country variables in the GM-estimations also support the notion of production fragmentation, not only for the variables measuring factor endowment just like the ML-estimations. We can also compare our results from Table 3 with the results from Table 3A, where we row-standardize our weighting matrix. As

[31] The low spatial autocorrelation estimate is due to the spatial expansion and the inclusion of country dummies (or the demeaning). The initial spatial autocorrelation without these is in the range of 0.5.

[32] In Table 2 and 2a, we do not use dummies to control for country characteristics. Instead we demean the data by the relevant variables and run our regressions on the demeaned data, thereby getting rid of potential dummy endogeneity.

[33] All the investing countries are developed, hence their capital endowments are still relatively close. We can also note that when only bilateral variables are used, the effect of the capital endowment ratio is positive and significant, both in the random effects as well as the GM-estimation. Hence the exclusion of third country variables can induce severe errors in our estimations.

in the MLE case, the implied spatial dependence is inflated confirming again our suspicion that issues of normalization matter.

In general, the estimations seem to indicate horizontal bilateral motivations dominate the reasons for investing in a host country and the magnitude of the coefficients is reasonably in line with prior research. However, third country effects that are both vertically motivated, but also seem to be important as final good consumers seem to play an important role. These results hold irrespective of methodology chosen and are robust in their support for significant third country effects and the existence of spatial interdependence of FDI locations.

5 Conclusions

The purpose of this paper has been the investigation of the existence and nature of spatial (inter)dependencies of FDI locations. We have used a large set of country pair data on real outward FDI stocks, covering a large majority of world FDI. By modelling spatial dependencies emanating both from the explanatory variables and the errors, and using both maximum likelihood and general moments estimations, we find that the notion of spatial dependence of FDI locations is strongly supported.

To wit, FDI is mainly driven by bilateral determinants that support horizontal motivations while third country effects tend to support vertical motivations, both in terms of the results with respect to third country factor endowments and trade costs. The results are in line with the notion of MNEs forming regional supply chains of production, where the third country determinants act as complements to bilateral FDI. The additional finding that surrounding market potential is important increases the complexity of these interdependencies. These results support the existence of complementary FDI, indicate that the tyranny of distance has probably lessened and that forces of dispersion have increased in importance. As in Blonigen et al. (2007) the bilateral estimation does not seem to be grossly mis-specified by the exclusion of spatial dependencies, since the coefficients on the bilateral determinants are, mostly, quantitatively similar .

Finally, as in the theoretical literature, so also in the empirical field the spatial nature of the "New Economic Geography" and the theory of Multinational Enterprises need to be explored further. Moreover, theoretical models that are easily implemented empirically need to be developed in order to give clearer directions about potential spatial relationships.

References:

Anselin, L. 1988. Spatial econometrics: Methods and models. Dordrecht, the Netherlands: Kluwer.

Anselin, L., and Bera, A., 1998. Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics. Ch. 7, 237-289. in Aman Ullah and David Giles (eds.) *Handbook of Applied Economic Statistics* (New York: Marcel Dekker).

Baltagi, B. H., Egger P., Pfaffermayr M., 2003. A generatlized design for bilateral trade flow models. Economic Letters 80: 391-97.

Baltagi, B. H., Egger P., Pfaffermayr M., 2007. Estimating models of complex FDI: Are there third-country effects? Journal of Econometrics, 140, 260-281.

Bergstrand, J. H, Egger, P., 2007. A Knowledge-and-Physical-Capital Model of International Trade, Foreign Direct Investment, and Foreign Affiliate Sales: Developed Countries. Journal of International Economics, forthcoming.

Bloningen, B.A., Davies, R.B, 2004, The Effects of Bilateral Tax Treaties on U.S. FDI Activity. International Tax and Public Finance, 11, 601-22.

Bloningen, B.A., Davies, R.B., Head, K., 2003, Estimating the Knowledge-Capital Model of the Multinational Enterprise: Comment, The American Economic Review, 93, 980-994.

Blonigen, B.A., Davies, R.B., Waddell, G.R., Naughton, H.T., 2007 . FDI in space. European Economic Review, forthcoming

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.L., Markusen, J.R., Maskus, K.E., 2001, Estimating the Knowledge-Capital Model of the Multinational Enterprise, The American Economic Review, 91, 693-708.

Casetti,E. 1972, Generating Models by the Expansion Method: Applications to Geographic Research, Geographical Analysis, 4,.81-91.

Casetti, E. 1992. Bayesian Regression and the Expansion Method, Geographical Analysis, 24, 58-74.

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

Ekholm, K., Forslid, R., Markusen, J.R., 2007. Export-platform foreign direct investment. Journal of the European Economic Association, 5, 776-795.

Elhorst P.J., 2003. Specification and Estimation of Spatial Panel Data Models. International Regional Science Review, 26, 244-268

Feinberg, S.E., Keane M. P., 2003. Accounting for the Growth of MNC-based Trade using a Structural Model of US MNCs. Mimeo.

Grossman, G.M., Helpman, E., Szeidl, A., 2006. Optimal integration strategies for the multinational firm. Journal of International Economics, 70, 216-38..

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

Helpman, E., Krugman, P.R., 1985. Market Structure and International Trade. MIT Press, Cambridge, MA.

Helpman, E., Melitz, M.J., Yeaple, S.R., 2004. Export versus FDI with heterogenous firms. American Economic Review, 94, 300–316.

Kaldor, N., 1970. The Case for Regional Policies. Scottish Journal of Political Economy, 17, 337-48.

Kapoor, M., Kelejian, H.H., Prucha, I.R., 2007. Panel data models with spatially correlated error components. Journal of Econometrics, 140, 97-130.

Kelejian, H.H., Prucha, I.R., 1998. A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. Journal of Real Estate Finance and Economics, 17, 99–121.

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

Krugman, P., 1991. Geography and Trade. MIT press. Cambridge

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., Makus, K.E., 2002. Discriminating Among Alternative Theories of the Multinational Enterprise. Review of International Economics, 10, 694-707.

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

Markusen, J.R., Venables, A.J., 2007. Interacting factor endowments and trade costs: a multi-country, multi-good approach to trade theory. Journal of International Economics, 73, 333-354.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica, 71, 1695– 1725.

Myrdal , G., 1957. Economic Theory and Underdeveloped Regions, London, Ducksworth.

Pesaran, H., Smith, R.P., 1995. Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics, 68,79-113. Reprinted in The International Library of Critical Writings in Econometrics, Recent Developments in the Econometrics of Panel Data, B. Baltagi (ed), 2002.

Tobler, W. 1970. A computer movie simulating urban growth in the Detroit region. Economic Geography 46:234–40.

Von Thünen H., 1826. Der isolierte Staat in Beziehung auf Landwirtschaft und Nationaloekonomie. Translated by Wartenberg and Hall, von Thünen's isolated state, 1966.

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.

Yi, K.-M., 2003, Can vertical specialization explain the growth of world trade? Journal of Political Economy, 111, 52-102.

Table 1: OLS Regressions on Outward FDI Stock, Spatial Expansion. Dependent Variable: Log of Real Outward FDI. 1994-2004

	Model 1 (BE)		Model 2 (RE)		Model 3 (FE)		Model 4 (Origin and Host)		Model 5 (Host)		Model 6 (Host)	
Bilateral Variables												
l GDP sum	2.86***	(7.86)	3.13***	(11.57)	4.37**	(2.70)	2.94	(1.34)	4.72***	(37.43)	4.20***	(36.12)
l Sim. Index	1.15***	(3.27)	0.98***	(3.20)	0.35	(0.31)	1.28	(1.18)	2.14***	(20.19)	2.13***	(20.74)
l Cap.Ratio.	-0.28	(1.14)	-0.08	(0.40)	0.90	(1.24)	0.02	(0.02)	0.61	(0.73)	3.53***	(18.85)
l Trade cost host	-0.98*	(1.68)	-1.01***	(3.28)	-0.77*	(1.87)	-0.71	(1.17)	-0.80	(1.22	-0.74	(1.14)
l Trade cost orig.	-0.72	(1.36)	-0.60	(1.44)	-0.60	(0.70)	-2.64*	(1.88)	-2.43***	(11.63)	-2.61***	(14.62)
l Fin. Risk host	6.22***	(3.45)	-0.31	(0.86)	-0.63	(1.59)	-1.09*	(1.72)	-0.98	(1.50)	-1.17*	(1.80)
l |Skill diff.|	0.24	(1.24)	-0.08	(0.90)	-0.10	(0.98)	-0.13**	(2.53)	-0.14**	(2.57)	-0.14**	(2.38)
Tradech*skilld^2	0.35	(0.49)	0.97***	(2.89)	1.03**	(2.14)	-0.45*	(1.89)	0.09	(0.38)	-0.10	(0.42)
|GDPd|*|Skilld|	1.9 e^{-07}	(0.73)	-5.5^{-08}**	(2.47)	-1e^{-07}**	(2.58)	-2e^{-09}	(0.24)	2.9 e^{-09}	(0.38)	-4.8 e^{-09}	(0.64)
l distance	-1.40***	(5.20)	-1.81***	(7.13)	--	--	-1.08***	(6.43)	-1.28***	(8.51)	-0.96***	(11.25)
Weighted Third Country Variables												
l W GDP	2.38**	(2.38)	0.54	(0.88)	0.63	(0.24)	5.03***	(6.89)	6.04***	(8.52)		
l W Sim. Index	-0.63*	(1.66)	-0.86***	(2.66)	-1.11	(1.00)	-3.21***	(3.57)	-3.42***	(3.64)		
l W Cap.Ratio	2.18***	(3.42)	3.85***	(8.52)	3.98***	(3.16)	4.14***	(2.73)	2.85***	(3.56)		
l W |Skill diff.|	0.81***	(4.23)	0.30***	(3.25)	0.16	(0.14)	0.12	(0.90)	0.39***	(2.62)		
l W Trade cost host	-3.03**	(2.07)	1.25	(1.48)	0.34	(0.25)	-5.76***	(3.29)	-0.62***	(3.65)		
Obs.	3577		3577		3577		3577		3577		3577	
R^2	0.52		0.31		0.08 /(0.86)		0.60		0.53		0.51	
rho (variance due to u_i)			0.82		0.93							
F-stat					49.08 (448)		78.8 (69)		75.9 (53)		78.8 (48)	

Note: Time and country dummies included but not reported. Absolute robust t-statistics in parenthesis. *,**,*** denote significance in the 10-5 and 1% -level respectively
The R squared varies depending on estimation method. The between (model 1), overall (model 2), within (model 3) and adjusted (model 3-6) is used.

Table 2: Demeaned Regressions on Outward FDI Stock, Spatial Expansion and Spatial Error Model. Dependent Variable: Log of Real Outward FDI. 1994-2004

	Demeaned Spatial Expansion Estimations (OLS)								Demeaned MLE Estimations: Spatial Error Model							
	Model 3		Model 4		Model 5		Model 6		Model 3		Model 4		Model 5		Model 6	
Bilateral Variables																
l GDP sum	4.51***	(3.63)	2.47***	(2.95)	4.71***	(37.61)	4.20***	(36.32)	4.89***	(5.21)	2.49***	(3.93)	4.93***	(42.66)	4.53***	(39.74)
l Sim. Index	0.42	(0.43)	1.11**	(2.72)	2.14***	(20.25)	2.13***	(20.85)	0.72	(0.99)	1.12***	(3.61)	2.22***	(25.75)	2.20***	(26.29)
l Cap.Ratio.	0.93	(1.38)	0.31	(0.43)	0.60	(0.73)	3.53***	(18.96)	1.19**	(2.41)	0.34	(0.63)	0.86	(1.44)	3.47***	(18.85)
l Trade cost host	-0.77**	(2.01)	-0.49	(0.90)	-0.74	(1.14)	-0.73	(1.14)	-0.85**	(3.08)	-0.51	(1.24)	-0.77*	(1.66)	-0.71	(1.52)
l Trade cost orig.	-0.63	(0.84)	-1.12	(0.88)	-2.39***	(11.59)	-2.61***	(14.70)	-0.54	(0.83)	-1.15	(1.18)	-2.81***	(15.59)	-3.22***	(19.11)
l Fin. Risk host	-0.62	(1.70)	-1.25**	(2.13)	-1.03	(1.58)	-1.17*	(1.82)	-0.62**	(2.36)	-1.23***	(2.81)	-0.99**	(2.10)	-1.04**	(2.23)
l |Skill diff.|	-0.10	(1.05)	-0.13**	(2.39)	-0.15**	(2.58)	-0.14**	(2.39)	-0.11	(1.60)	-0.13**	(3.14)	-0.13***	(3.11)	-0.13***	(3.00)
Tradech*skilld^2	1.04**	(2.31)	-0.45*	(1.88)	0.09	(0.37)	-0.10	(0.42)	1.18***	(3.61)	-0.45**	(2.50)	0.04	(0.24)	-0.10	(0.55)
|GDPd|*|Skilld|	-1e^{-07} **	(2.78)	-3.4e^{-09}	(0.41)	2.3e^{-09}	(0.31)	-4.8e^{-09}	(0.65)	-7e^{-08}***	(3.62)	-3.3e^{-09}	(0.52)	-2.2e^{-09}	(0.40)	-8.7e^{-09}	(1.51)
l distance			-1.33***	(11.28)	-1.31***	(8.84)	-0.96***	(8.84)			-1.34***	(15.02)	-1.61***	(12.44)	-1.16***	(14.90)
Weighted Third Country Var.																
l W GDP	0.92	(0.51)	4.58***	(6.89)	5.86***	(8.41)			0.66	(0.50)	4.61***	(9.20)	5.43***	(10.41)		
l W Sim. Index	-1.18	(1.23)	-1.95**	(2.84)	-3.40***	(3.64)			-1.23*	(1.77)	-1.97***	(3.78)	-3.25***	(4.77)		
l W Cap.Ratio	3.98***	(3.37)	2.92**	(2.68)	2.86***	(3.59)			3.48***	(3.69)	2.87***	(3.47)	2.79***	(4.69)		
l W |Skill diff.|	0.02	(0.17)	0.20	(1.60)	0.38**	(2.62)			-0.03	(0.33)	0.20**	(2.15)	0.31***	(2.96)		
l W Trade cost host	0.51	(0.42)	-2.07	(1.52)	-5.86**	(3.37)			0.54	(0.60)	-2.15**	(2.08)	-4.13***	(3.09)		
Spatial autocorr. (δ)									0.09***	(8.56)	0.01	(0.62)	0.15***	(21.35)	0.16***	(22.49)
R^2	0.02		0.07		0.45		0.43		0.26		0.23		0.58		0.57	
F-stat/LL	6.9		18		194		270		-7743		-11791		-12243		-12313	
σ^2									1.51		5.23		5.61		5.80	

Note: Absolute robust t-statistics in parenthesis. *,**,*** denote significance in the 10, 5 and 1% -level respectively

Table 2A: Demeaned Regressions on Outward FDI Stock, Spatial Expansion and Spatial Error Model, Different Weighting Matrices. Dependent Variable: Log of Real Outward FDI. 1994-2004.

	Demeaned MLE Estimations: Spatial Error Model W is row normalized								**Demeaned MLE Estimations: Spatial Error Model W is not row normalized**							
	Model 3		Model 4		Model 5		Model 6		Model 3		Model 4		Model 5		Model 6	
Bilateral Variables																
l GDP sum	5.22***	(5.53)	2.65***	(3.82)	4.91***	(27.09)	4.45***	(25.71)	4.89***	(5.21)	2.49***	(3.93)	4.93***	(42.66)	4.53***	(39.74)
l Sim. Index	1.19	(1.63)	1.18***	(3.49)	2.23***	(20.38)	2.16***	(20.73)	0.72	(0.99)	1.12***	(3.61)	2.22***	(25.75)	2.20***	(26.29)
l Cap.Ratio.	1.33***	(2.68)	0.37	(0.68)	0.64	(1.14)	3.14***	(11.79)	1.19**	(2.41)	0.34	(0.63)	0.86	(1.44)	3.47***	(18.85)
l Trade cost host	-0.83***	(3.02)	-0.57	(1.39)	-0.62	(1.40)	-0.40	(0.90)	-0.85**	(3.08)	-0.51	(1.24)	-0.77*	(1.66)	-0.71	(1.52)
l Trade cost orig.	-0.51	(0.76)	-1.06	(0.96)	-2.75***	(10.08)	-3.16***	(12.30)	-0.54	(0.83)	-1.15	(1.18)	-2.81***	(15.59)	-3.22***	(19.11)
l Fin. Risk host	-0.57**	(2.14)	-1.13**	(2.57)	-0.71	(1.58)	-0.68	(1.53)	-0.62**	(2.36)	-1.23***	(2.81)	-0.99**	(2.10)	-1.04**	(2.23)
l |Skill diff.|	-0.10	(1.56)	-0.12***	(3.08)	-0.11***	(2.74)	-0.10***	(2.60)	-0.11	(1.60)	-0.13**	(3.14)	-0.13***	(3.11)	-0.13***	(3.00)
Tradech*skilld^2	1.15***	(3.56)	-0.48***	(2.72)	-0.42**	(2.43)	-0.60***	(3.44)	1.18***	(3.61)	-0.45**	(2.50)	0.04	(0.24)	-0.10	(0.55)
|GDPd|*|Skilld|	$-7e^{-08}$**	(2.36)	$-3e^{-09}$	(0.40)	$-2e^{-10}$	(0.03)	$-3e^{-09}$	(0.64)	$-7e^{-08}$***	(3.62)	$-3.3e^{-09}$	(0.52)	$-2.2e^{-09}$	(0.40)	$-8.7e^{-09}$	(1.51)
l distance			-1.38***	(14.68)	-1.46***	(11.47)	-1.02***	(14.33)			-1.34***	(15.02)	-1.61***	(12.44)	-1.16***	(14.90)
Weighted Third Country Var.																
l W GDP	0.57	(0.42)	4.76***	(9.33)	5.23***	(9.91)			0.66	(0.50)	4.61***	(9.20)	5.43***	(10.41)		
l W Sim. Index	-1.49**	(2.13)	-2.23***	(4.13)	-3.56***	(5.63)			-1.23*	(1.77)	-1.97***	(3.78)	-3.25***	(4.77)		
l W Cap.Ratio	3.40***	(3.56)	2.69***	(3.08)	2.95***	(4.96)			3.48***	(3.69)	2.87***	(3.47)	2.79***	(4.69)		
l W |Skill diff.|	0.03	(0.35)	0.20**	(2.19)	0.23**	(2.30)			-0.03	(0.33)	0.20**	(2.15)	0.31***	(2.96)		
l W Trade cost host	0.56	(0.61)	-2.76**	(2.51)	-4.95***	(3.69)			0.54	(0.60)	-2.15**	(2.08)	-4.13***	(3.09)		
Spatial autocorr. (δ)	0.19***	(6.36)	0.16***	(4.93)	0.60***	(33.98)	0.58***	(32.43)	0.09***	(8.56)	0.01	(0.62)	0.15***	(21.35)	0.16***	(22.49)
R^2	0.26		0.25		0.63		0.62		0.26		0.23		0.58		0.57	
F-stat/LL	-7745		-11786		-12028		-12097		-7743		-11791		-12243		-12313	
σ^2	1.51		5.10		5.03		5.18		1.51		5.23		5.61		5.81	

Note: Absolute robust t-statistics in parenthesis. *,**,*** denote significance in the 10, 5 and 1% -level respectively

Table 3: Random Effects and GM- Estimation on Outward FDI Stock: Spatial Expansion, Spatially and Time-wise Correlated Errors. Dependent Variable: Log of Real Outward FDI. 1994-2004.

	Random Effects Estimation		GM-Estimation, Spatially correlated Errors		Random Effects Estimation		GM-Estimation, Spatially correlated Errors	
Bilateral Variables								
l GDP sum	3.13***	(11.57)	3.19***	(19.27)	2.88***	(11.90)	2.66***	(17.95)
l Sim. Index	0.98***	(3.20)	1.17***	(6.96)	0.76***	(2.64)	0.81***	(5.06)
l Cap.Ratio.	-0.08	(0.40)	-0.30***	(2.64)	0.68***	(3.69)	0.23**	(2.22)
l Trade cost host	-1.01***	(3.28)	-1.25***	(5.03)	-0.90***	(3.03)	-0.82***	(3.71)
l Trade cost orig.	-0.60	(1.44)	-1.13***	(4.39)	-0.80*	(1.93)	-0.85***	(3.09)
l Fin. Risk host	-0.31	(0.86)	1.48***	(3.21)	-0.29	(0.80)	1.75***	(3.70)
l |Skill diff.|	-0.08	(0.90)	0.04	(0.55)	-0.13	(1.46)	-0.08	(0.95)
Tradech*skilld^2	0.97***	(2.89)	0.28	(0.98)	0.66*	(1.91)	0.16	(0.54)
|GDPd|*|Skilld|	-5.5e^{-08}**	(2.47)	-2.1e^{-08}*	(1.70)	3.3e^{-08}*	(1.81)	-2.0e^{-08}	(1.48)
l distance	-1.81***	(7.13)	-1.81***	(12.50)	-0.81***	(4.64)	-0.64***	(6.14)
Weighted Third Country Var.								
l W GDP	0.54	(0.88)	1.50***	(3.48)				
l W Sim. Index	-0.86***	(2.66)	-0.47***	(2.74)				
l W Cap.Ratio	3.85***	(8.52)	3.91***	(13.31)				
l W |Skill diff.|	0.30***	(3.25)	0.73***	(9.15)				
l W Trade cost host	1.25	(1.48)	-0.72	(1.12)				
Spatial autocorr. (δ)			0.097				0.134	
σ_{vv}^2	1.51		4.34		1.51		4.59	
σ_{11}^2	3.22		31.05		3.36		33.61	

Note: Absolute robust t-statistics in parenthesis. *,**,*** denote significance in the 10, 5 and 1% -level respectively
The GM-estimation does not provide a significance level for the spatial autocorrelation like the MLE

Table 3A: GM- Estimation on Outward FDI Stock: Spatial Expansion, Spatially and Time-wise Correlated Errors.
Dependent Variable: Log of Real Outward FDI. 1994-2004.

	GM-Estimation, parsimonious model		GM-Estimation, parsimonious model		GM-Estimation, Row normalized weights		GM-Estimation, Row normalized weights	
Bilateral Variables								
l GDP sum	2.57***	(17.04)	3.10***	(18.78)	1.97***	(12.36)	2.69***	(14.93)
l Sim. Index	0.76***	(4.66)	1.13***	(6.59)	0.46***	(2.98)	0.88***	(5.17)
l Cap.Ratio.	0.28***	(2.71)	-0.28**	(2.42)	0.03	(0.75)	-0.26**	(2.42)
l Trade cost host	-0.69***	(3.14)	-1.20***	(4.77)	-0.29	(1.33)	-0.99***	(4.00)
l Trade cost orig.	-0.76***	(2.74)	-1.06***	(4.09)	0.28	(0.87)	-0..38	(1.31)
l Fin. Risk host					1.40***	(3.05)	1.22***	(2.69)
l |Skill diff.|	-0.08	(1.01)	0.04	(0.46)	-0.05	(0.65)	0.03	(0.43)
Tradech*skilld^2	0.17	(2.89)	0.31	(1.10)	-0.004	(0.01)	0.03	(0.09)
|GDPd|*|Skilld|	-1.6e^{-08}	(1.31)	-1.9e^{-08}	(1.57)	1.1e^{-08}	(0.88)	-1.4 e^{-08}	(1.12)
l distance	-0.61***	(5.73)	-1.83***	(12.39)	-0.61***	(6.09)	-1.64***	(11.50)
Weighted Third Country Var.								
l W GDP			1.41***	(3.24)			1.57***	(3.73)
l W Sim. Index			-0.43**	(2.47)			-0.25	(1.45)
l W Cap.Ratio			3.94***	(13.26)			3.27***	(9.94)
l W |Skill diff.|			0.72***	(9.01)			0.68***	(8.68)
l W Trade cost host			-0.68	(1.04)			-1.22*	(1.90)
Spatial autocorr. (δ)	0.137		0.099		0.51		0.41	
σ_{vv}^2	4.46		4.23		4.29		4.15	
σ_{11}^2	34.92		32.25		29.24		27.75	

Note: Absolute robust t-statistics in parenthesis. *,**,*** denote significance in the 10, 5 and 1% -level respectively
The GM-estimation does not provide a significance level for the spatial autocorrelation like the MLE

APPENDIX A

Covariance Matrix and Descriptive Statistics of main explanatory variable

	lGDP sum	lSim. Index	lCap.Ratio.	lTrade cost h	lTrade cost o.	l Fin Risk h.	l|Sk.diff.|	lWGDP	lWSim. Index	l W Kap.R.	l W |Skilldiff.|	l W Trade c.h.
l GDP sum	**1**											
l Sim. Index	-0.68	**1**										
l Cap.Ratio.	-0.05	0.05	**1**									
l Trade cost h	0.32	-0.11	0.15	**1**								
l Trade cost o.	0.57	-0.41	0.07	0.01	**1**							
l Fin. Risk host	-0.10	0.04	0.36	0.14	-0.08	**1**						
l |Skill diff.|	0.02	-0.03	0.25	0.10	0.06	0.10	**1**					
l W GDP	-0.08	0.17	-0.46	-0.55	-0.09	-0.38	-0.18	**1**				
l W Sim. Ind	0.25	0.11	0.31	0.51	0.02	0.21	0.09	-0.26	**1**			
l W Cap.R.	0.05	-0.08	0.58	0.40	0.05	0.39	0.15	-0.84	0.31	**1**		
l W |Skill diff.|	-0.04	0.01	-0.38	-0.24	0.04	-0.22	-0.13	0.45	-0.25	-0.69	**1**	
l W Trade cost. h.	-0.03	0.08	-0.49	-0.43	0.03	-0.47	-0.17	0.88	-0.32	-0.91	0.68	**1**

	Mean	Max	Min	St. Dev.
l rfdi	6.51	12.74	-11.51	4.00
l GDP sum	13.93	16.57	11.50	1.14
l Sim. Index	-1.39	-0.69	-4.55	0.80
l Cap.Ratio.	0.50	3.71	-1.11	0.95
l Trade cost host	-4.04	-2.78	-5.23	0.53
l Trade cost orig.	-4.13	-2.78	-5.23	0.51
l Fin. Risk host	-3.67	-2.87	-3.91	0.14
l |Skill diff.|	0.51	2.12	-11.15	1.05
l W GDP	14.13	15.46	12.59	0.68
l W Sim. Index	-1.45	-0.69	-3.13	0.62
l W Cap.Ratio	-0.38	1.45	-2.22	0.90
l W |Skill diff.|	1.65	3.65	-8.74	1.72
l W Trade cost host	-3.49	-2.31	-4.86	0.60

Test for restrictions of country dummies

Likelihood-ratio test	*LR χ^2(16)*	*=624.32*
(Assumption: 5 nested in 4)	*Prob> χ^2*	*=0*
Likelihood-ratio test	*LR χ^2 (379)=*	*=4101.51*
(Assumption: 4 nested in 3)	*Prob>χ^2*	*=0*
F-test for valid restrictions		
From Model 3 to Model 4	*F(476,3028)*	*=13.67*
	Prob > F	*=0*
From Model 3 to Model 5	*F(493,3028)*	*=16.88*
	Prob > F	*=0*

APPENDIX B

Expected signs of main variables depending on mode of FDI:

	Market Access Motivations	Production Fragmentation Motivations
Bilateral Variables		
l GDP sum	+	+
l Sim. Index	+	+/-
l Cap.Ratio	+	+
l Trade cost host	+	-
l Trade cost orig.	+/-	-
l Fin. Risk host	-	-
l |Skill diff.|	-	+
l distance	-	-
W X variables		
l W GDP	+	+
l W Sim. Index	+	+/-
l W Cap.Ratio	-	+
l W |Skill diff.|	-	+
l W Trade cost host	+/-	-

APPENDIX C

Quick Data Appendix

All real variables have 2000 as base year.
Producer Price Indices are from the Bank of International Settlements.
Bilateral FDI are from Eurostat: http://epp.eurostat.ec.europa.eu
Real Outward FDI stock is deflated by host country PPI .
Skill is measured as the average number of schooling years for the population of age>25, (tyr) from the Barro-Lee dataset. Since they come in 5 year intervals we have made a spline extrapolation in order to obtain annual data that vary over time.
Real GDP, and Real Openness are from PWT 6.1. Real Investment is calculated from PWT 6.1 by multiplying the variables rgdpl*(ki/100).
Depreciation is assumed to be 7 %.
The Financial Risk Index is from International Country Risk Guide.

For a FDI_{ij}
(i) denotes country of origin
(j) denotes host country
(k) denotes host countries other than (j) in the sample.
and W is our distance based weighting matrix

Similarity index: $$SimX = \left(1 - \left(\frac{X_i}{X_i + X_j}\right)^2 - \left(\frac{X_j}{X_i + X_j}\right)^2\right); \quad SimX \in [0;0.5]$$

Real Capital Stock 1994: $\sum_{1970}^{1993} R.Invest/head * depreciation$

Capital Stock at time t = Capital Stock (t-1)*depreciation + Real Investment at time t.

Capital Ratio = $\frac{K_{origin}}{K_{host}}$ W Capital Ratio= $\frac{K_{origin}}{WK_{host}}$

Skill difference: $|Skill_{origin} - Skill_{host}|$

W Skill D. $|Skill_{host,j} - W\ Skill_{hosts,\ k}|$

Trade Cost: 1/Real Openness

Investment Cost: 1/Financial Risk Index

Great Circle Distances between Capital Cities was obtained from http://www.wcrl.ars.usda.gov/cec/java/capitals.htm

W GDP: is $WGDP_k$ for the FDI stock from country(i) in country(j)

W Trade cost host: is WTrade-$cost_k$ for the FDI stock from country(i) in country(j)

Country Sample:

Countries of Origin: Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA

Countries of Destination: Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, USA, Argentina, Australia, Brazil, Canada, Chile, China, India, Indonesia, Korea, Mexico, New Zealand, Philippines.