Spatial Determinants of Foreign Direct Investment

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Abstract

FDI flows grew exponentially during the 1990s, experienced a sharp decline over the period 2001-2004, and have recently started to recover. The decline was mostly due to a fall in FDI flows within the OECD, particularly of FDI flows to continental Europe. In recent years, FDI flows to developing countries have also increased substantially. This trend has been encouraged by governments who view it as a safer form of finance. In this paper we investigate whether the characteristics and policies of countries within a regional market interact to determine the location of FDI. In particular, we study the impact of tax policy on FDI given the policies adopted by neighbouring countries, and test the implications of New Economic Geography (NEG) models of tax competition for the effectiveness of tax policy in the core and the periphery of regional markets. The model is estimated using a bi-parametric spatial panel data estimator, which allows for spatial autocorrelation in the origins and destinations of FDI.

JEL: F20, H87, C23. **Keywords:** Foreign Direct Investment, Tax Competition, Spatial Econometrics, Panel Data.

1 Introduction

Foreign Direct Investment (FDI) has steadily grown in importance since the early 1990s. A period of exponential growth during the 1990s was followed by a period of decline over 2001-2004, and there is some recent evidence of recovery. The decline over the period 2001-2004 was mostly due to a fall in FDI destined to France and Germany, while FDI flows to developing countries increased substantially over the same period. FDI flows to developing countries have been promoted by governments who view FDI as a safer form of finance, in contrast to short-term capital flows (Fernández-Arias and Hausmann, 2000).

The growing importance of FDI to developing countries, and the frequent shifts in the trends, have generated intense debate over the factors that determine FDI. Since most FDI still occurs within the industrialised world, researchers have argued that the horizontal or market-seeking motive for FDI prevails over the vertical, or resource-seeking motive.

Horizontal FDI occurs when a firm sets up a plant abroad in order to supply the foreign market. In doing so it foregoes economies of scale at the plant level (since it must duplicate part of its production activities abroad), and incurs additional fixed costs when setting up the foreign plant. The firm will therefore only invest abroad if the foreign market is large, and if the transport costs are such that serving

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the foreign market through exports is expensive. If the size of the foreign market is small, the firm will generally be better off exporting (Markusen and Venables, 2000).

Vertical FDI, on the other hand, occurs when a firm exploits international differences in factor prices by moving part of its production process abroad. The benefits of producing some intermediate goods in a lower-cost location compensate for the loss of integration economies in the production process, and the cost of shipping the intermediate products back to the home plant (Helpman, 1984). Unlike horizontal FDI, vertical FDI is greater the lower are transport costs. It will therefore tend to occur between countries that are located closer together, or linked via free trade agreements (e.g., US firms producing in Mexico).

The horizontal and vertical models of FDI can be nested in the 'knowledge-capital model' (Markusen, 2002), where the type of FDI is determined endogenously. More specifically, the knowledge-capital model predicts that a large potential market and high transport costs encourage horizontal FDI, while large differences in factor endowments and low transport costs result in vertical FDI.

Since it is generally impossible to empirically separate the two types of FDI due to data limitations, most empirical studies estimate a model that includes determinants of both horizontal and vertical FDI. They have generally found that the determinants of horizontal FDI have a greater impact on FDI flows than the determinants of vertical FDI, and this provides some evidence that horizontal FDI is more prevalent (Brainard, 1997; Carr et al., 2001). Intuitively this result makes sense since most FDI occurs between the industrialised countries, which are fairly similar in terms of size and factor endowments.

The literature on FDI has also argued that the model of horizontal FDI can be used to explain FDI flows into a regional market (e.g. the EU), with a firm considering transport costs and the size of the whole market in order to decide whether to locate a plant in the region (Navaretti and Venables, 2004). An increase in the degree of regional integration (or falling regional transport costs) over time can therefore provide an explanation for the observed increase in FDI over time.

Once a firm has decided to invest in a region in order to supply the local market, the question becomes where in the region it will locate the plant. The analysis in this paper focuses on the impact of corporate taxes on FDI. This is an interesting policy variable to study for several reasons. The experience of Ireland has shown that FDI-led development strategies can be successful, and one of the main policies pursued by the Irish government has been to keep corporate taxes low (Navaretti and Venables, 2004). In addition, there are several contradictory theoretical predictions regarding the effectiveness of taxes in attracting mobile capital. Finally, there has been some discussion in the literature regarding the benefits of tax coordination among regional governments, an issue of relevence in the context of spatial interaction models.

The standard tax competition model predicts that non-cooperative actions by governments will result in taxes falling to a sub-optimal level (the so-called 'race to the bottom'). If countries are symmetric in size, competition results in the lowest possible tax rate, implying a transfer of resources from the country's residents to the multinational firm. If countries differ in size, the country that is abundant in the fixed factor will be able to set a higher tax rate, since the marginal product of the mobile factor is larger than in the mobile-factor-abundant country. The relative location of a country with respect to the other is irrelevant in this model.

An equilibrium tax gap in the presence of size asymmetries is also possible under imperfect competition, although for different reasons. The larger country is able to set a positive profit tax, so that the multinational is indifferent between the larger country with a positive tax rate, and the smaller country with a nominally zero tax rate (Haufler and Wooton, 1999). The size of the tax differential between the two countries is greater the larger are the per-unit transport costs between the two countries, since higher transport costs make supplying the larger market from the smaller market more expensive. This model therefore explicitly incorporates space in the form of transport costs between the two countries.

Recently, the new economic geography literature has shown that an equilibrium tax gap is possible in the presence of agglomeration rents (Baldwin and Krugman, 2004). The country in which industry is agglomerated (the 'core') can charge a fairly high tax rate because agglomeration rents turn the mobile factor into a quasi-fixed factor, that is, the multinational will be unwilling to relocate to the periphery unless the tax rate in the core is prohibitively high. The equilibrium tax gap is greatest for intermediate levels of transport costs (i.e. for intermediate levels of regional integration). At high transport costs agglomeration is not feasible (exporting is too costly), while at low transport costs agglomeration is not necessary (location becomes irrelevant). The model can therefore explain the tax differential observed in the EU between the core and periphery countries, and the recent narrowing of the tax differential as the integration progress deepens. Borck and Pflüger (2004) show that this result also holds in the case of partial agglomeration.

Empirically, a number of studies have found that taxes have a positive impact on the location of FDI, with the average tax rate elasticity being in the order -3.3 (De Mooij and Ederveen, 2001). That is, a 1% reduction in the destination-country tax rate results in an additional 3.3% of investment. A number of studies have also found that the impact of taxes depends on the provision of public services, or the degree of industrial concentration already present in the regional economy (Wheeler and Mody, 1992; Head et al., 1999; Hubert and Pain, 2002).

The analysis in this paper contributes to the literature on the location of FDI in two ways. First, previous spatial econometric analyses of FDI have focused on the determinants of outward FDI originating in the United States, and destined to other OECD countries (Blonigen et al., 2004; Baltagi et al., 2004). In this paper the sample is extended to include a number of developing-country destinations, and origins other than the United States. This extension is important particularly in the context of the third-country effects, that is, when the decision to invest in one country is affected by the characteristics and policies of other potential destinations. The reasons that prompt US firms to invest in a given country may be specific to the relationship between the US and the destination country, for instance because they share a common language, or a common colonial past. Including origins other than the US allows us to control for these factors. The inclusion of developing-country destinations is interesting since it allows us to study competition for FDI within regional markets other than the EU, such as Mercosur and ASEAN.

The second innovation of this paper is to derive an estimator for a spatial error model with spatial autocorrelation in the origins and the destinations of FDI. Previous spatial-econometric studies of FDI have allowed for the presence of spatial autocorrelation in the destinations of FDI, but a different type of estimator is needed for the model proposed in this paper, since there is more than one origin country. Spatial autocorrelation in the origins can occur if firms in two countries that are located close together, for instance the United States and Canada, tend to invest in a third country for reasons other than those that are captured by the explanatory variables included in the model, for instance, because the third-country market is of particular strategic importance for North-American firms. In addition, shocks that are spatial in nature, such as regional economic downturns, can cause the errors to be spatially correlated.

The remainder of the paper is organised as follows. Section 2 describes the empirical approach to be followed in the analysis, and derives the bi-parametric estimator. Section 3 discusses the empirical results, and Section 4 concludes.

2 Empirical Approach

The bilateral nature of the FDI model considered in this paper raises a number of important estimation issues. The first of these issues is the need to account for the bilateral-relationship specific effects, that is, unobservable time-invariant characteristics specific to each bilateral FDI relationship. Some examples of these would be cultural affinities not captured by the variables in the model, bilateral investment treaties, preferential trade agreements and tax treaties.

The second important issue that arises is the appropriateness of existing spatial econometric models for dealing with spatial autocorrelation in the context of bilateral data. This issue has been discussed at some length in the context of travel-flow models, where origins and destinations are likely to be spatially autocorrelated (Brandsma and Ketellaper, 1979; Bolduc et al., 1992). In the case of FDI, unobserved characteristics in the destination countries such as tastes, institutions, infrastructure and geographical variables such as climate and topology are likely to be spatially correlated, as are unobservable characteristics in the origin countries. The travel flow literature has addressed this problem by including an additional spatial parameter in the specification of the error of the model, so that the errors of the origins and the errors of the destinations are spatially correlated. The inclusion of this term changes the nature of the spatial model, and results in a likelihood function with two nonlinear equations in the two spatial error paramaters (Brandsma and Ketellaper, 1979), which is then estimated using maximum likelihood.

A biparametric approach has been used in the spatial econometrics literature to allow for complex forms of spatial weights (Rietveld and Wintershoven, 1998), also resulting in a complex likelihood function. The use of maximum likelihood estimation is, however, not always feasible, due to the computational requirements involved in calculating the eigenvalues of the spatial weights matrix, the matrix that contains information on the relative location of the cross-sectional units in the model.

Given that maximum likelihood estimation of biparametric models with large datasets is computationally difficult, and given the need to control for unobserved relationship-specific effects, the estimator used in this paper is an extension of the Generalized Moments (GM) estimator for panel data derived in Kapoor et al. (2003), which in turn is based on Kelijian and Prucha (1999), a cross-sectional estimator. The Kelejian and Prucha (1999) estimator has been extended in Bell and Bockstael (2000) to allow for multiple weights matrices. The contribution of the analysis in this paper is to demonstrate that the Kapoor et al. (2003) estimator can be extended to include multiple weights.

2.1 A Biparametric Spatial Panel Data Estimator

The estimator employed in this paper allows the disturbances to be correlated over time and across spatial units. The error term is allowed to depend on the unobserved characteristics of other origin and destination countries located within a given distance range. The model is linear of the form:

$$y_N(t) = X_N(t)\beta + u_N(t), \tag{1}$$

where $y_N(t)$ denotes a vector of N observations for the dependent variable at time t, $X_N(t)$ is a matrix of observations on the explanatory variables, β is a vector of parameters and $u_N(t)$ is a vector of disturbance terms. The vector $u_N(t)$ follows first-order spatial autoregressive processes of the form:

$$u_N(t) = \rho_1 W_{1,N} u_N(t) + \rho_2 W_{2,N} u_N(t) + \varepsilon_N(t), \tag{2}$$

where W_1 is a spatial weights matrix that captures the location of origin countries with respect to other origin countries, and W_2 is a spatial weights matrix that captures the location of destination countries. W_1 and W_2 are defined:

$$W_{.,N} = \begin{cases} w_{ij} = 1/d_{ij} & \text{if } i \neq j \text{ and } d_{ij} \leqslant 6000 \text{ miles} \\ w_{ij} = 0 & \text{if } i \neq j \text{ and } d_{ij} > 6000 \text{ miles} \end{cases} \tag{3}$$

where d_{ij} denotes the bilateral distance between i and j in miles.[1] The two spatial weights matrices are of dimension $N \times N$, and have been constructed by stacking the observations first by the origins and then by the destinations. The matrices have also been row-standardised, so that the elements in each row sum to 1. Stacking the observations over time gives:

$$y = X\beta + u \tag{4}$$

and

$$u = \rho_1 (I_T \otimes W_{1,N}) u + \rho_2 (I_T \otimes W_{2,N}) u + \varepsilon \tag{5}$$

where $y = [y'_N(1), ..., y'_N(T)]'$, $X = [X'_N(1), ..., X'_N(T)]'$, $u = [u'_N(1), ..., u'_N(T)]'$, and $\varepsilon = [\varepsilon'_N(1), ..., \varepsilon'_N(T)]'$.

To allow the observations to be correlated across time, the vector ε is given by:

$$\varepsilon = (\iota_T \otimes I_N)\mu + \nu \tag{6}$$

where μ is a vector of unit specific error components, distributed with zero mean and variance σ^2_μ, and ν is a vector of disturbances that are uncorrelated over time and across space, distributed with mean zero and variance σ^2_υ, and ι_T is a $T \times 1$ vector of ones. The variance-covariance matrix of ε is:

$$\begin{aligned} \Omega_{\varepsilon,N} &= E[\varepsilon' \varepsilon] \\ &= \sigma^2_\mu (J_T \otimes I_N) + \sigma^2_\nu I_{NT} \\ &= \sigma^2_\upsilon Q_0 + \sigma^2_1 Q_1, \end{aligned} \tag{7}$$

where $\sigma^2_1 = \sigma^2_\upsilon + T\sigma^2_\mu$, and

$$Q_0 = (I_T - \frac{J_T}{T}) \otimes I_N, \tag{8}$$

$$Q_1 = \frac{J_T}{T} \otimes I_N, \tag{9}$$

where $J_T = \iota_T \iota'_T$ is a $T \times T$ matrix of unit elements.

Pre-multiplication of a vector by Q_0 implies a transformation whereby the average value for each unit over time is subtracted from each element of the vector, while pre-multiplication by Q_1 returns

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[1] The cut-off point of 6,000 miles was chosen to allow the countries in South and South-East-Asia and Latin America to be directly spatially linked, since empirical and annecdotal evidence suggests that there is substantial competition among the countries in these regions for FDI. A sensitivity analysis in Appendix C shows that varying the cut-off distance has no substantive effect on the estimates.

the average value for each unit over time. Intuitively, the Q_0 transformation eliminates the bilateral-relationship specific effects, i.e. $Q_0\varepsilon = Q_0\nu$.

In deriving the moment conditions, the following notation will be used:

$$\begin{aligned} \overline{\varepsilon}_1 &= (I_T \otimes W_{1,N})\varepsilon && (10) \\ \overline{\varepsilon}_2 &= (I_T \otimes W_{2,N})\varepsilon, && (11) \end{aligned}$$

and

$$\begin{aligned} \overline{u}_1 &= (I_T \otimes W_{1,N})u && (12) \\ \overline{u}_2 &= (I_T \otimes W_{2,N})u \\ \overline{u}_{11} &= (I_T \otimes W_{1,N})\overline{u}_1 \\ \overline{u}_{22} &= (I_T \otimes W_{2,N})\overline{u}_2 && (13) \\ \overline{u}_{12} &= (I_T \otimes W_{1,N})\overline{u}_2, \end{aligned}$$

where a bar over a variable indicates its spatial lag, while the subscript indicates the spatial weights matrix used to compute the spatial lag.

The moment conditions used in the estimator are given by:

$$\begin{bmatrix} \frac{1}{N(T-1)}\varepsilon' Q_0 \varepsilon \\ \frac{1}{N(T-1)}\overline{\varepsilon}_1' Q_0 \overline{\varepsilon}_1 \\ \frac{1}{N(T-1)}\overline{\varepsilon}_2' Q_0 \overline{\varepsilon}_2 \\ \frac{1}{N(T-1)}\overline{\varepsilon}_1' Q_0 \overline{\varepsilon}_2 \\ \frac{1}{N(T-1)}\overline{\varepsilon}_1' Q_0 \varepsilon \\ \frac{1}{N(T-1)}\overline{\varepsilon}_2' Q_0 \varepsilon \\ \frac{1}{N}\varepsilon' Q_1 \varepsilon \\ \frac{1}{N}\overline{\varepsilon}_1' Q_1 \overline{\varepsilon}_1 \\ \frac{1}{N}\overline{\varepsilon}_2' Q_1 \overline{\varepsilon}_2 \\ \frac{1}{N}\overline{\varepsilon}_1' Q_1 \overline{\varepsilon}_2 \\ \frac{1}{N}\overline{\varepsilon}_1' Q_1 \varepsilon \\ \frac{1}{N}\overline{\varepsilon}_2' Q_1 \varepsilon \end{bmatrix} = \begin{bmatrix} \sigma_v^2 \\ \sigma_v^2 \frac{1}{N} tr(W_{1,N}' W_{1,N}) \\ \sigma_v^2 \frac{1}{N} tr(W_{2,N}' W_{2,N}) \\ \sigma_v^2 \frac{1}{N} tr(W_{1,N}' W_{2,N}) \\ 0 \\ 0 \\ \sigma_1^2 \\ \sigma_1^2 \frac{1}{N} tr(W_{1,N}' W_{1,N}) \\ \sigma_1^2 \frac{1}{N} tr(W_{2,N}' W_{2,N}) \\ \sigma_1^2 \frac{1}{N} tr(W_{1,N}' W_{2,N}) \\ 0 \\ 0 \end{bmatrix}, \qquad (14)$$

which generalize the moment conditions derived in Kapoor et al. (2003) to allow for an additional spatial weights matrix in the error term u. The derivation of the moment conditions is shown in Appendix A.

In order to derive a system of equations involving the moments of u, we note:

$$\begin{aligned} \varepsilon &= u - \rho_1 \overline{u}_1 - \rho_2 \overline{u}_2 && (15) \\ \overline{\varepsilon}_1 &= \overline{u}_1 - \rho_1 \overline{u}_{11} - \rho_2 \overline{u}_{12} \\ \overline{\varepsilon}_2 &= \overline{u}_2 - \rho_1 \overline{u}_{21} - \rho_2 \overline{u}_{22}. \end{aligned}$$

Substituting these expressions into equation (14) results in a system of twelve equations in the parameters ρ_1, ρ_2, σ_v^2 and σ_1^2, of the form:

$$\Gamma[\rho_1, \rho_2, \rho_1\rho_2, \rho_1^2, \rho_2^2, \sigma_v^2, \sigma_1^2]' - \gamma = 0. \tag{16}$$

The full system is shown in Appendix B.

The expressions to be used in the estimator are the sample counterparts of the equations in system (16). Denoting the estimators of β and u by $\tilde{\beta}$ and $\tilde{u}$, the sample analogue of the system in (16) is given by:

$$G_N[\rho_1, \rho_2, \rho_1\rho_2, \rho_1^2, \rho_2^2, \sigma_v^2, \sigma_1^2]' - g_N = \xi(\rho_1, \rho_2, \sigma_v^2, \sigma_1^2), \tag{17}$$

where $\xi(\rho_1, \rho_2, \sigma_v^2, \sigma_1^2)$ is a vector of residuals. The elements of (17) are identical to those of (16), except that the expected value of u has been replaced by $\tilde{u}$.

The estimation procedure consists of three stages. In the first stage, equation (4) is estimated using Ordinary Least Squares (OLS), and the residuals are collected. In the second stage, the residuals $\tilde{u}$ from the OLS regression are substituted into equation (17), which is minimized to obtain estimates of $\tilde{\rho}_1, \tilde{\rho}_2, \tilde{\sigma}_v^2$ and $\tilde{\sigma}_1^2$. In the third stage, these estimates are used in a GLS estimator described below to compute the remaining coefficients of the model, i.e. the vector $\tilde{\beta}$.

When estimating the parameters $\rho_1, \rho_2, \sigma_v^2$ and σ_1^2 in the second stage, the method employed in this paper follows Kapoor et al. (2003) in that we first obtain preliminary estimates using a subset of the moment conditions, and these estimates are then used to construct a weighting matrix to assign different weights to the full set of moment conditions.[2] The preliminary estimates of $\rho_1, \rho_2, \sigma_v^2$ are calculated as:

$$(\tilde{\rho}_1, \tilde{\rho}_2, \tilde{\sigma}_v^2) = \arg\min\{\xi^0(\rho_1, \rho_2, \sigma_v^2)'\xi^0(\rho_1, \rho_2, \sigma_v^2)\}, \tag{18}$$

using a non-linear least-squares estimator and the first six moment conditions, were we make use of the fact that the first six moment conditions involve only $\rho_1, \rho_2, \sigma_v^2$, while the final six conditions involve $\rho_1, \rho_2, \sigma_1^2$. Using the estimates $\tilde{\rho}_1, \tilde{\rho}_2, \tilde{\sigma}_v^2$ obtained using the first six moment conditions, an estimate $\tilde{\sigma}_1^2$ can be obtained from the seventh moment condition.

Given $\tilde{\rho}_1, \tilde{\rho}_2, \tilde{\sigma}_v^2$ and $\tilde{\sigma}_1^2$, a more efficient estimator of the parameters is:

$$(\check{\rho}_1, \check{\rho}_2, \check{\sigma}_v^2, \check{\sigma}_1^2) = \arg\min\{\xi^0(\rho_1, \rho_2, \sigma_v^2, \sigma_1^2)'\tilde{\Upsilon}^{-1}\xi^0(\rho_1, \rho_2, \sigma_v^2, \sigma_1^2)\}, \tag{19}$$

where the sample moments are weighted by $\tilde{\Upsilon}^{-1}$, which is an approximation of the inverse of the variance-covariance matrix of the sample moments. $\tilde{\Upsilon}$ is given by:

$$\Upsilon = \begin{bmatrix} \frac{1}{T-1}\sigma^4 & 0 \\ 0 & \sigma_1^4 \end{bmatrix} \otimes I_6. \tag{20}$$

The initial estimates of $\tilde{\sigma}_v^2, \tilde{\sigma}_1^2$ based on the first seven moment conditions are used to calculate $\tilde{\Upsilon}^{-1}$, which is then used in equation (19) to obtain more efficient estimates of the parameters $\rho_1, \rho_2, \sigma_v^2$ and σ_1^2.[3]

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[2] Intuitively, more weight is given to the moment conditions with less uncertainty. Hansen (1982) shows that setting the weights matrix of the GM procedure equal to the inverse of the asymptotic covariance matrix yields parameter estimates with the smallest asymptotic variance.

[3] A sensitivity analysis shows that there is virtually no difference between the final estimation results if only a subset of moment conditions is used, or if a full variance-covariance matrix is specified in place of the approximation used in this study. This approximation approach was used because it makes use of all the information provided by the moment

Given these efficient estimates, denoted $\check{\rho}_1, \check{\rho}_2, \check{\sigma}_v^2$ and $\check{\sigma}_1^2$, in the third stage the remaining estimates of the model are found using a GLS procedure. A spatial Cochrane-Orcutt type of transformation is applied to the original model, yielding:

$$y^*(\rho_1, \rho_2) = X^*(\rho_1, \rho_2)\beta + u, \tag{21}$$

where

$$\begin{aligned} y^*(\rho_1, \rho_2) &= [I_T \otimes (I_N - \rho_1 W_{1,N} - \rho_2 W_{2,N})]y, \\ X^*(\rho_1, \rho_2) &= [I_T \otimes (I_N - \rho_1 W_{1,N} - \rho_2 W_{2,N})]X. \end{aligned} \tag{22}$$

The model is then transformed a second time by pre-multiplying y^* and X^* by:

$$I_{NT} - \theta Q_1, \tag{23}$$

where $\theta = 1 - \sigma_\nu^2/\sigma_1$.The feasible GLS estimator of β is then equivalent to the OLS estimator obtained on the twice-transformed model, where $\rho_1, \rho_2, \sigma_v^2, \sigma_1^2$ are replaced by the estimates $\check{\rho}_1, \check{\rho}_2, \check{\sigma}_v^2, \check{\sigma}_1^2$ in equations (21) and (23). The transformation in equation (23) is equivalent to subtracting from each variable its mean over time multiplied by θ (see Kapoor et al., 2005).

2.2 Empirical Specification

We first consider a baseline specification that includes the main determinants of horizontal and vertical FDI. The knowledge-capital model predicts that horizontal multinational sales will be larger the larger are the origin and destination markets, the higher are trade barriers, and the lower are plant fixed costs in the destination country, while vertical multinational sales will be larger the lower are trade barriers, and the larger are differences in factor endowments between the origin and the destination countries.

The variables included in the baseline specification are therefore the size of the origin and destination markets, the bilateral distance between the two countries, and the costs of exporting to the destination country (in the form of a measure of openness to trade). In addition, education in the destination country is included as a measure of factor endowments, and an index of economic freedom is included as a measure of the plant fixed costs in the destination market. As controls we also include a dummy that equals one if the two countries share a common language, a dummy for a colonial relationship and a dummy for contiguity. Finally, the baseline specification includes the average corporate tax rate in the destination country, which is the policy variable that we focus on in this study. The expectation is that taxes have a negative impact on FDI. The sources and characteristics of the data used in this study are detailed in Section 2.3. All the variables, with the exception of the dummies, are included in logs.

Our second specification takes the broader view that the horizontal FDI model also explains export-platform FDI, that is, FDI with a view to supply other countries in the market. This is the case considered by Blonigen et al. (2004) and Baltagi et al. (2004), two previous spatial econometric studies of FDI. To the baseline specification we add two additional variables, the spatially lagged size of the market, that is, the average size of neighbouring countries, and spatially lagged openness. These two variables reflect, respectively, the incentives for investment in terms of the potential market, and the costs of supplying

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conditions, while being computationally simpler than the full matrix approach. Estimation using the full set of moment conditions with no weighting was found to be highly inefficient. A similar result was found by Kapoor et al. (2005).

that market through exports.

A third specification considers, in addition to the variables included in the second specification, the interaction between country size and taxes. By including this variable we want to test a prediction of the new economic geography models on tax competition discussed in Section 5.1, which is that the core can set higher tax without driving away the mobile factor, because of the presence of agglomeration rents. In this case we proxy agglomeration rents by the size of the market, and interpret the definition of the core narrowly in the sense that the core is just one country.

Finally, a fourth specification interprets the definition of the core differently, in the sense that the core can now be a group of countries, surrounded by a group of periphery countries. An example would be the core formed by Italy, France, Germany, The Netherlands and the United Kingdom in Europe, surrounded by a periphery formed by Ireland, Spain, Portugal and the Eastern European countries. This is the wider interpretation proposed by Baldwin and Krugman (2004). In this case we include an interaction term composed of taxes in the destination, and the spatially lagged market size.

In addition to these variables, all the specifications contain time dummies.

2.3 Data Characteristics

The dependent variable used in the analysis is the log of the real FDI stock, taken from the OECD Direct Investment Statistics database, which covers outward positions from the OECD member countries to their principal trading partners. While the data are available over the period 1980-2003, the coverage is fairly limited for 1980-1990 and 2002-2003. The analysis is therefore restricted to the period 1988-2001. The data were complemented using data on outward FDI positions provided by the UNCTAD World Investment Report.[4]

The FDI stocks, in current local currency units, were deflated using the GDP deflator of the IMF International Finance Statistics, and converted to constant US dollars using exchange rates taken from the OECD Direct Investment Statistics.[5]

As a measure of market size, we use GDP in constant PPP dollars, taken from the Penn World Table 6.1. Data on bilateral distance between capital cities (in miles), contiguity, common official language, colonial relationship, latitude and longitude were taken from the CEPII database.

Our measure of education is the average years of schooling in the population aged 25 and over, taken from the Barro and Lee (2001) database. The Economic Freedom Index and our measure of openness of trade are taken from the Economic Freedom of the World Report of the Fraser Institute. For these three variables, values in the years not covered by the original sources were imputed using linear interpolation.

Average tax rates were calculated using an ex-post method, with data on the foreign affiliates of US-based multinationals taken from the BEA. We divided the amount of corporate income taxes payed by foreign affiliates in their destination countries by their gross operating surplus (pre-tax profits) in those countries. Since US companies are required to pay income tax in their destination countries in exchange

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[4] The UNCTAD dataset covers a large number of origin and destination countries, but the coverage is limited for countries other than the OECD and its main trading partners. We therefore restricted the sample to the origins and destinations of the OECD dataset, and used the UNCTAD data if the OECD data was missing, or an average if both were available.

[5] Missing data points were filled using observations from the previous or the following year, or an average of the two if both were available. 27% of data points were still missing after this procedure. Given that we could not assign zero values to the missing observations, due to the double-log specification of the model, we assigned them the value of 1000 US dollars. The reason for this choice is that all values below 1,000 US dollars are not reported in the sources we used, and setting a value of 1 dollar generates very extreme results, given that the dependent variable is in logs. Changing the value assigned to missing observations does not affect the substantive conclusions of the analysis; it only affects the magnitude of the coefficients.

for a tax credit in the US, these tax rates are a fairly accurate measure of the corporate income tax rates faced by multinational companies in the destination countries. Data on the US corporate tax rate were similarly calculated using data on provided by the BEA for foreign multinationals operating in the US.[6]

The following 15 origin countries are included: Australia, Austria, Canada, France, Germany, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Sweden, United Kingdom, and USA.

There are 43 destination countries: Argentina, Australia, Austria, Belgium and Luxembourg, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Panama, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, USA, and Venezuela.

The dataset covers a period of 14 years, from 1988 to 2001.

3 Estimation Results

The first column in Table 1 shows the estimation results corresponding to the baseline specification. The coefficients have the expected sign for the market potential variables, indicating that firms in larger origin countries are more likely to invest abroad, while larger destination countries are more likely to receive FDI. This result is supportive of the horizontal FDI model.

The coefficient on distance is negative, which is contrary to the predictions of the horizontal FDI model, and supportive of the vertical FDI model. This result is also in line with previous findings in the literature. Anecdotal evidence in the business economics literature suggests that multinationals are more likely to invest in countries that are located within their regional market, simply because they understand the market and the legal conditions better. This factor is equivalent to assuming that the plant level costs increase with distance, and in this sense the result could also be consistent with the horizontal FDI model.

The coefficient on the contiguity variable is negative, but not significant, indicating that the bulk of FDI does not go to the origin countries' immediate neighbours, all other things being equal. This result is consistent with the horizontal FDI motive, which posits that neighbouring markets are supplied through exports if the trade costs are low. The coefficient of the openness variable is also negative, indicating that FDI is preferred when trade costs are high. The coefficients of the control variables are also as expected. Multinationals tend to invest in countries were the population speaks the same language, and in countries that are related to their home market via a colonial relationship.

The effect of education on FDI is positive and highly significant. An 1% increase in the the average years of schooling of the population results in an additional 5.3% of FDI. Economic freedom also has a substantial positive effect on FDI, indicating that economic policy and economic uncertainty are important determinants of FDI, adding to or reducing the costs of setting up and managing a foreign plant.

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[6] The literature on tax competition has discussed at some length the appropriateness of various measures of corporate taxes. In essence there are two methods. An ex-post macro-economic method calculates the tax rate as the ratio between the taxes paid by corporations and the gross operating surplus of corporations. An ex-ante micro-economic method uses the features of the tax code to calculate a 'theoretical' tax rate (Devereux and Griffith, 1998). The advantage of the ex-post method is that it is based on actual taxes paid, rather than on the theoretical tax rate. The disadvantage is that the tax measures based on the ex-post method are affected by factors external to the domestic tax code, for instance, foreign tax regulations. In order to test the robustness of our results, we conducted a sensitivity analysis using an alternative, ex-ante, measure of corporate taxes (taken from Devereux et al., 2002). It should noted that this involves a substantial reduction in the number of destination countries, from 43 to 19. Most of the substantive conclusions of the analysis remain unchanged, although several of the coefficients are no longer statistically significant.

Table 1: Estimation results.

	(1)	(2)	(3)	(4)
Constant	-155.01^{***}	-170.26^{***}	-164.14^{***}	-109.46^{**}
	(28.65)	(49.92)	(50.93)	(53.75)
GDP (origin)	4.11^{***}	4.13^{***}	4.15^{***}	4.15^{***}
	(0.94)	(0.94)	(0.92)	(0.92)
GDP (destination)	1.54^{***}	1.51^{***}	1.35^{***}	1.60^{***}
	(0.32)	(0.32)	(0.36)	(0.32)
Distance	-1.51	-1.49	-1.50	-1.54
	(1.12)	(1.12)	(1.12)	(1.12)
Colony	0.52	0.55	0.53	0.41
	(2.44)	(2.42)	(2.38)	(2.39)
Common language	0.73	0.68	0.70	0.86
	(1.74)	(1.74)	(1.71)	(1.72)
Contiguity	-0.83	-0.76	-0.77	-0.85
	(2.67)	(2.66)	(2.60)	(2.62)
Taxes (destination)	-0.27^{***}	-0.27^{***}	-1.64	-17.13^{***}
	(0.08)	(0.08)	(1.31)	(5.18)
Education (destination)	5.33^{***}	5.19^{***}	5.19^{***}	4.89^{***}
	(0.80)	(0.83)	(0.84)	(0.85)
Econ. freedom (destination)	3.50^{***}	3.35^{***}	3.42^{***}	3.52^{***}
	(0.74)	(0.77)	(0.79)	(0.79)
Openness (destination)	-0.51	-0.33	-0.38	-0.37
	(0.35)	(0.42)	(0.43)	(0.43)
$W_2\times$ GDP		0.54	0.42	-1.87
		(1.52)	(1.56)	(1.71)
$W_2\times$ Openness		0.95	0.98	0.94
		(1.07)	(1.11)	(1.10)
Taxes $\times$ GDP			0.05	
			(0.05)	
Taxes $\times$ $W_2\times$ GDP				0.64^{***}
				(0.20)
ρ_1	0.17	0.18	0.19	0.19
ρ_2	0.71	0.71	0.71	0.71
σ_μ	7.83	7.78	7.66	7.69
σ_ν	7.82	7.84	7.89	7.88
Observations	8820	8820	8820	8820

Standard errors are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. All variables with the exception of Contiguity, Common Language and Colony are in logs; the interactions terms are composed of two variables in logs. The dependent variable is the log of the real FDI stock. Time dummies are included in all the regressions.

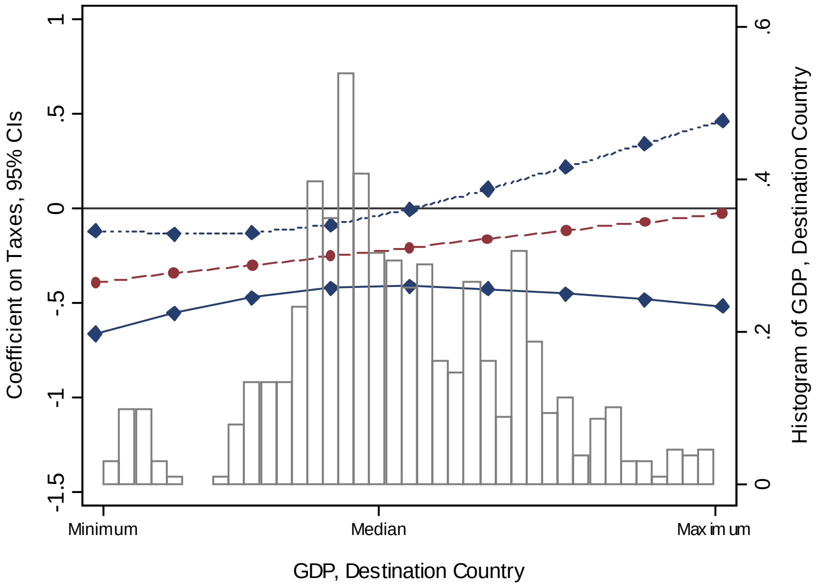

Figure 1: Effect of taxes on FDI at different levels of GDP.

The estimates of the spatial error coefficients indicate that there is spatial autocorrelation in the origins and in the destinations, but that the degree of spatial autocorrelation is greater in the destinations. This is a reasonable result, given that spatially correlated factors such as climate, topology, conflict and so on are more likely to affect FDI if they occur in the destinations. Moreover, the origins are in general a fairly homogenous set of countries.

The second column in Table 1 corresponds to the second specification discussed above, where horizontal FDI is interpreted broadly to include export-platform FDI. The results for the variables of the baseline specification are very similar to those in column (1), with all coefficients retaining their signs and significance levels. The two new variables of interest are the spatially lagged market size, and spatially lagged openness. The hypothesis was that a larger regional market, and a greater degree of regional openness have a positive effect on FDI to any country in the region. The results indicate that the two coefficients have the expected sign, but are not significantly different from zero.

Column (3) shows the results of the third specification, which now includes an interaction term between taxes and market size. The introduction of the interaction term changes the interpretation of the coefficients of the variables making up the term, which now measure the marginal effect of each variable on FDI given that the other variable takes a value of zero. The results of this specification can be analysed using a diagram, shown in Figure 1.

Figure 1 plots the effect of taxes on FDI, at different levels of GDP.[7] The histogram shows the distribution of GDP, and the innermost of the three lines shows the coefficient of taxes at different levels of GDP, with the two outer lines plotting the 95% confidence intervals. The effect of taxes on FDI is negative at low levels of GDP, and approaches zero at high levels of GDP. In terms of the predictions of the new economic geography model on tax competition, the results indicate that the core countries are

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[7] The diagram was constructed by plotting the values taken by the coefficient of taxes in regressions which were centered on different values of GDP. The 95% confidence intervals were constructed with the corresponding standard errors.

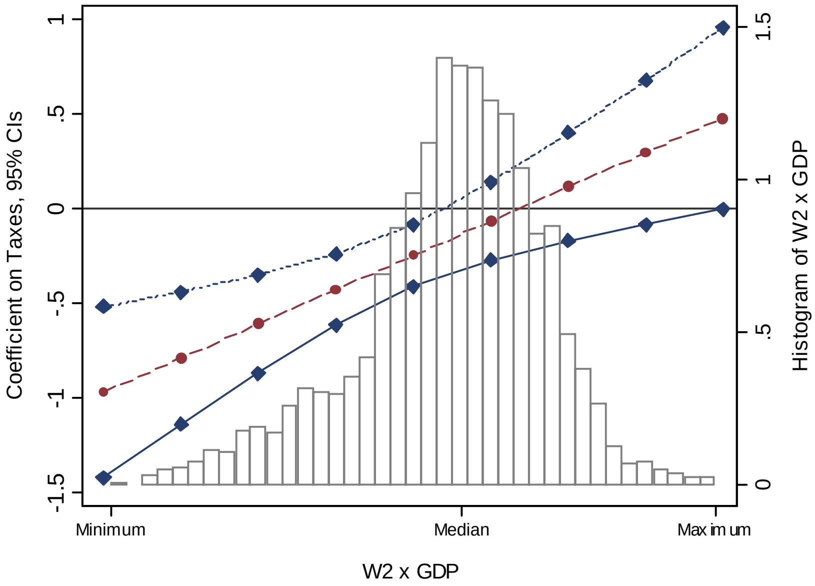

Figure 2: Effect of taxes on FDI at different levels of W_2 x GDP

able to increase their tax rates without losing FDI, while an increase in tax rates in periphery countries results in a significant negative shift in FDI. The results of this specification are therefore in line with the predictions of the new economic geography model, in its narrower interpretation.

The results of the final specification, incorporating an interaction term between taxes and the spatially lagged market size, are shown in column (4) of Table 1. Once again, the inclusion of the interaction term changes the interpretation of the coefficients of the lower order terms, and the results are better understood with the aid of a diagram. Figure 2 plots the coefficient of taxes at different levels of the spatially lagged market size.

The results indicate that for countries situated in the regional periphery, an increase in taxes can have a devastating effect on FDI. At very low values of spatially lagged GDP, the effect of taxes on FDI approaches -1, indicating that a 1% increase in taxes reduces FDI by 1 percentage point. For countries situated in the core, the result is surprising, an increase in taxes leads to an increase in FDI. The prediction of the new economic geography model of tax competition is that FDI is unresponsive to increases in taxes in the core. The reason for the observed result could be that for the countries in the core, an increase in taxes signals an improvement in infrastructure or other factor that attracts more FDI. Alternatively, it could be that during the period under consideration, there was a simultaneous increase in taxes in the core countries (the race to the top discussed in Baldwin and Krugman, 2004) and an increase in FDI attracted by the agglomeration rents already present in the core.

4 Conclusions

This paper considers whether the characteristics and policies of countries within a regional market interact to determine the location of FDI. The literature has identified two motives for FDI, both of which have a spatial dimension. Horizontal FDI occurs when a firm invests in a foreign country in order to supply the foreign market, either the market in the destination country, or according to a wider interpretation the regional market. The decision to invest and the size of the investments are greater the greater are the origin and destination markets, and the higher are the costs of trading between the two countries. The trading costs are modelled in this paper using bilateral distance between the two markets, and the openness to trade of the destination country. Vertical FDI, occurs when a firm invests in a foreign country in order save costs, and ultimately to supply the home market. In this case, trading costs are a detriment to FDI, and we would expect the effect on FDI to be negative.

The results of the analysis partially support both motives for FDI. The coefficients of the market size variables are positive, and the effect of openness on FDI is negative, both of which are supportive of the horizontal FDI model. However, the coefficient on distance is negative, which supports the predictions of the vertical FDI model.

We also show that taxes are an effective policy tool for attracting FDI only in the case of small countries, that is, countries with small markets. The implication is that large countries should focus on other factors, such as human capital. Paradoxically, it was also found that raising taxes can have a positive impact on FDI for countries surrounded by very large countries, a result that requires further analysis.

This paper also introduced a random effects spatial error estimator that allows for spatial autocorrelation in the origins and destinations of FDI. The results indicate that spatial autocorrelation is greater among the destinations than among the origins, implying that omitted variables with a spatial dimension, and spatially correlated shocks have a greater impact on the choice of destination, than on the competition among firms from spatially autocorrelated origins to invest in a particular destination. The estimator developed in this paper could be applied in the analysis of travel flow models and other bilateral flow models, for instance gravity models.

A Moment Conditions

The derivation of the moment conditions in (14) is based on the properties of the matrices Q_0 and Q_1. These matrices are symmetric, idempotent and orthogonal, and

$$\begin{aligned} Q_0 + Q_1 &= I_{NT}, \\ tr(Q_0) &= N(T-1), \\ tr(Q_1) &= N, \\ Q_0(\iota_T \otimes I_N) &= 0, \\ Q_1(\iota_T \otimes I_N) &= (\iota_T \otimes I_N). \end{aligned} \tag{24}$$

In addition, for any $N \times N$ matrix A

$$\begin{aligned} (I_T \otimes A)Q_0 &= Q_0(I_T \otimes A), \\ (I_T \otimes A)Q_0 &= Q_0(I_T \otimes A), \\ tr(Q_0(I_T \otimes A)) &= (T-1)tr(A), \\ tr(Q_1(I_T \otimes A)) &= tr(A), \end{aligned} \tag{25}$$

observing that for any $T \times T$ matrix B we have $tr(B \otimes A) = tr(B)tr(A)$.

From these properties it follows:

$$\begin{aligned}
Q_0\varepsilon &= Q_0\nu, \\
Q_1\varepsilon &= (\iota_T \otimes I_N)\mu + Q_1\nu, \\
Q_0\overline{\varepsilon}_1 &= (I_T \otimes W_{1,N})Q_0\nu, \\
Q_0\overline{\varepsilon}_2 &= (I_T \otimes W_{2,N})Q_0\nu, \\
Q_1\overline{\varepsilon}_1 &= (\iota_T \otimes W_{1,N})\mu + (I_T \otimes W_{1,N})Q_1\nu, \\
Q_1\overline{\varepsilon}_2 &= (\iota_T \otimes W_{2,N})\mu + (I_T \otimes W_{2,N})Q_1\nu.
\end{aligned} \tag{26}$$

Recall that by assumption $E\mu\mu' = \sigma_\mu^2 I_N$, $E\nu\nu' = \sigma_\nu^2 I_{NT}$ and $E((\iota_T \otimes I_N)\mu)\nu' = 0$, and note that for any $N \times 1$ random vector η and $N \times N$ matrix A, $E(\eta' A\eta) = tr(AE\eta\eta')$.[8] Using these expressions, we have:

$$\begin{aligned}
E\left[\varepsilon' Q_0 \varepsilon\right] &= E[\nu' Q_0 \nu], \\
&= \sigma_\nu^2 tr(Q_0), \\
&= \sigma_\nu^2 N(T-1), \\
E\left[\overline{\varepsilon}_1' Q_0 \overline{\varepsilon}_1\right] &= E[\nu'(I_T \otimes W_{1,N})'(I_T \otimes W_{1,N})Q_0\nu], \\
&= \sigma_\nu^2 tr\left[(I_T \otimes W_{1,N}' W_{1,N})Q_0\right], \\
&= \sigma_\nu^2 (T-1) tr(W_{1,N}' W_{1,N}), \\
E\left[\overline{\varepsilon}_2' Q_0 \overline{\varepsilon}_2\right] &= E[\nu'(I_T \otimes W_{2,N})'(I_T \otimes W_{2,N})Q_0\nu], \\
&= \sigma_\nu^2 tr\left[(I_T \otimes W_{2,N}' W_{2,N})Q_0\right], \\
&= \sigma_\nu^2 (T-1) tr(W_{2,N}' W_{2,N}), \\
E\left[\overline{\varepsilon}_1' Q_0 \overline{\varepsilon}_2\right] &= E[\nu'(I_T \otimes W_{1,N})'(I_T \otimes W_{2,N})Q_0\nu], \\
&= \sigma_\nu^2 tr\left[(I_T \otimes W_{1,N}' W_{2,N})Q_0\right], \\
&= \sigma_\nu^2 (T-1) tr(W_{1,N}' W_{2,N}), \\
E[\overline{\varepsilon}_1' Q_0 \varepsilon] &= E[\mu'(\iota_T' \otimes I_N)(I_T \otimes W_{1,N})' Q_0 \nu + \nu'(I_T \otimes W_{1,N}')Q_0\nu], \\
&= \sigma_\nu^2 tr[(I_T \otimes W_{1,N}')Q_0], \\
&= \sigma_\nu^2 tr(I_T \otimes W_{1,N}') tr Q_0 = 0, \\
E[\overline{\varepsilon}_2' Q_0 \varepsilon] &= E[\mu'(\iota_T' \otimes I_N)(I_T \otimes W_{2,N})' Q_0 \nu + \nu'(I_T \otimes W_{1,N}')Q_0\nu], \\
&= \sigma_\nu^2 tr[(I_T \otimes W_{2,N}')Q_0], \\
&= \sigma_\nu^2 tr(I_T \otimes W_{2,N}') tr Q_0 = 0, \\
E[\varepsilon' Q_1 \varepsilon] &= E[\mu'(\iota_T' \otimes I_N)(\iota_T \otimes I_N)\mu_N + \nu' Q_1 \nu], \\
&= \sigma_\mu^2 tr(\iota_T' \iota_T \otimes I_N) + \sigma_\nu^2 tr Q_1, \\
&= N\sigma_1^2, \\
E[\overline{\varepsilon}_1' Q_1 \overline{\varepsilon}_1] &= E[\mu'(\iota_T \otimes I_N)'(I_T \otimes W_{1,N})'(\iota_T \otimes W_{1,N}), \\
&\quad +\nu'(I_T \otimes W_{1,N})'(I_T \otimes W_{1,N})Q_1\nu], \\
&= \sigma_\mu^2 tr(\iota_T' \iota_T) tr(W_{1,N}' W_{1,N}) + \sigma_\nu^2 tr(W_{1,N}' W_{1,N}), \\
&= \sigma_1^2 tr(W_{1,N}' W_{1,N}),
\end{aligned} \tag{27}$$

---

[8] See, for example, Magnus and Neudecker (1988), p. 247.

$$
\begin{aligned}
E[\bar{\varepsilon}_2' Q_1 \bar{\varepsilon}_2] &= E[\mu'(\iota_T \otimes I_N)'(I_T \otimes W_{2,N})'(\iota_T \otimes W_{2,N}), \\
&\quad +\nu'(I_T \otimes W_{2,N})'(I_T \otimes W_{2,N})Q_1\nu], \\
&= \sigma_\mu^2 tr(\iota_T'\iota_T)tr(W_{2,N}'W_{2,N}) + \sigma_\nu^2 tr(W_{2,N}'W_{2,N}), \\
&= \sigma_1^2 tr(W_{2,N}'W_{2,N}), \\
E[\bar{\varepsilon}_1' Q_1 \bar{\varepsilon}_2] &= E[\mu'(\iota_T \otimes I_N)'(I_T \otimes W_{1,N})'(\iota_T \otimes W_{2,N}), \\
&\quad +\nu'(I_T \otimes W_{1,N})'(I_T \otimes W_{2,N})Q_1\nu], \\
&= \sigma_\mu^2 tr[(\iota_T' \otimes W_{1,N}')(\iota_T \otimes I_N)] + \sigma_\upsilon^2 tr(W_{1,N}'), \\
&= \sigma_1^2 tr(W_{1,N}'W_{2,N}), \\
E[\bar{\varepsilon}_1' Q_1 \varepsilon] &= E[\mu'(\iota_T' \otimes I_N)(I_T \otimes W_{1,N})'(\iota_T \otimes I_N)\mu, \\
&\quad +\nu'(I_T \otimes W_{1,N}')Q_1\nu], \\
&= \sigma_\mu^2 tr[(\iota_T' \otimes W_{1,N}')(\iota_T \otimes I_N)] + \sigma_\upsilon^2 tr(W_{1,N}'), \\
&= \sigma_\mu^2 T tr(W_{1,N}') + \sigma_\upsilon^2 tr(W_{1,N}') = 0, \\
E[\bar{\varepsilon}_2' Q_1 \varepsilon] &= E[\mu'(\iota_T' \otimes I_N)(I_T \otimes W_{2,N})'(\iota_T \otimes I_N)\mu, \\
&\quad +\nu'(I_T \otimes W_{2,N}')Q_1\nu], \\
&= \sigma_\mu^2 tr[(\iota_T' \otimes W_{2,N}')(\iota_T \otimes I_N)] + \sigma_\upsilon^2 tr(W_{2,N}'), \\
&= \sigma_\mu^2 T tr(W_{2,N}') + \sigma_\upsilon^2 tr(W_{2,N}') = 0,
\end{aligned}
$$

where $\sigma_1^2 = T\sigma_\mu^2 + \sigma_\upsilon^2$. The moment conditions in (14) follow directly from (27).

B System of Equations

The system of equations (16) is

$$\Gamma[\rho_1, \rho_2, \rho_1\rho_2, \rho_1^2, \rho_2^2, \sigma_\upsilon^2, \sigma_1^2]' - \gamma = 0,$$

where

$$
\Gamma = \begin{bmatrix}
\gamma_{11}^0 & \gamma_{12}^0 & \gamma_{13}^0 & \gamma_{14}^0 & \gamma_{15}^0 & \gamma_{16}^0 & 0 \\
\gamma_{21}^0 & \gamma_{22}^0 & \gamma_{23}^0 & \gamma_{24}^0 & \gamma_{25}^0 & \gamma_{26}^0 & 0 \\
\gamma_{31}^0 & \gamma_{32}^0 & \gamma_{33}^0 & \gamma_{34}^0 & \gamma_{35}^0 & \gamma_{36}^0 & 0 \\
\gamma_{41}^0 & \gamma_{42}^0 & \gamma_{43}^0 & \gamma_{44}^0 & \gamma_{45}^0 & \gamma_{46}^0 & 0 \\
\gamma_{51}^0 & \gamma_{52}^0 & \gamma_{53}^0 & \gamma_{54}^0 & \gamma_{55}^0 & \gamma_{56}^0 & 0 \\
\gamma_{61}^0 & \gamma_{62}^0 & \gamma_{63}^0 & \gamma_{64}^0 & \gamma_{65}^0 & \gamma_{66}^0 & 0 \\
\gamma_{11}^1 & \gamma_{12}^1 & \gamma_{13}^1 & \gamma_{14}^1 & \gamma_{15}^1 & & \gamma_{16}^1 \\
\gamma_{21}^1 & \gamma_{22}^1 & \gamma_{23}^1 & \gamma_{24}^1 & \gamma_{25}^1 & & \gamma_{26}^1 \\
\gamma_{31}^1 & \gamma_{32}^1 & \gamma_{33}^1 & \gamma_{34}^1 & \gamma_{35}^1 & & \gamma_{36}^1 \\
\gamma_{41}^1 & \gamma_{42}^1 & \gamma_{43}^1 & \gamma_{44}^1 & \gamma_{45}^1 & & \gamma_{46}^1 \\
\gamma_{51}^1 & \gamma_{52}^1 & \gamma_{53}^1 & \gamma_{54}^1 & \gamma_{55}^1 & & \gamma_{56}^1 \\
\gamma_{61}^1 & \gamma_{62}^1 & \gamma_{63}^1 & \gamma_{64}^1 & \gamma_{65}^1 & & \gamma_{66}^1
\end{bmatrix}, \quad
\gamma = \begin{bmatrix}
\gamma_1^0 \\ \gamma_2^0 \\ \gamma_3^0 \\ \gamma_4^0 \\ \gamma_5^0 \\ \gamma_6^0 \\ \gamma_1^1 \\ \gamma_2^1 \\ \gamma_3^1 \\ \gamma_4^1 \\ \gamma_5^1 \\ \gamma_6^1
\end{bmatrix}, \qquad (28)
$$

and for $i = 1, 0$

$$\begin{aligned}
\gamma_{11}^i &= \frac{2}{N(T-1)^{1-i}} E u' Q_0 \overline{u}_1, \\
\gamma_{12}^i &= \frac{2}{N(T-1)^{1-i}} E u' Q_0 \overline{u}_2, \\
\gamma_{13}^i &= \frac{-1}{N(T-1)^{1-i}} E \left[\overline{u}_1' Q_0 \overline{u}_2 + \overline{u}_2' Q_0 \overline{u}_1 \right], \\
\gamma_{14}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{u}_1' Q_0 \overline{u}_1, \\
\gamma_{15}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{u}_2' Q_0 \overline{u}_2, \\
\gamma_{16}^i &= 1,
\end{aligned}$$

$$\begin{aligned}
\gamma_{21}^i &= \frac{2}{N(T-1)^{1-i}} E \overline{u}' Q_0 \overline{\overline{u}}_{11}, \\
\gamma_{22}^i &= \frac{1}{N(T-1)^{1-i}} E \left[\overline{u}_1' Q_0 \overline{\overline{u}}_{12} + \overline{\overline{u}}_{12}' Q_0 \overline{u}_1 \right], \\
\gamma_{23}^i &= \frac{-1}{N(T-1)^{1-i}} E \left[\overline{\overline{u}}_{11}' Q_0 \overline{\overline{u}}_{12} + \overline{\overline{u}}_{12}' Q_0 \overline{\overline{u}}_{11} \right], \\
\gamma_{24}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{\overline{u}}_{11}' Q_0 \overline{\overline{u}}_{11}, \\
\gamma_{25}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{\overline{u}}_{12}' Q_0 \overline{\overline{u}}_{12}, \\
\gamma_{26}^i &= \frac{1}{N} tr(W_{1,N}' W_{1,N}),
\end{aligned}$$

$$\begin{aligned}
\gamma_{31}^i &= \frac{1}{N(T-1)^{1-i}} E \left[\overline{u}_2' Q_0 \overline{\overline{u}}_{21} + \overline{\overline{u}}_{21}' Q_0 \overline{\overline{u}}_2 \right], \\
\gamma_{32}^i &= \frac{2}{N(T-1)^{1-i}} E \overline{u}_2' Q_0 \overline{\overline{u}}_2, \\
\gamma_{33}^i &= \frac{-1}{N(T-1)^{1-i}} E \left[\overline{\overline{u}}_{21}' Q_0 \overline{\overline{u}}_{22} + \overline{\overline{u}}_{22}' Q_0 \overline{\overline{u}}_{21} \right], \\
\gamma_{34}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{\overline{u}}_{21}' Q_0 \overline{\overline{u}}_{21}, \\
\gamma_{35}^i &= \frac{-1}{N(T-1)^{1-i}} E \overline{\overline{u}}_{22}' Q_0 \overline{\overline{u}}_{22}, \\
\gamma_{36}^i &= \frac{1}{N} tr(W_{2,N}' W_{2,N}),
\end{aligned}$$

$$\begin{aligned}
\gamma_{41}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_1' Q_0 \overline{\overline{u}}_{21} + \overline{\overline{u}}_{11}' Q_0 \overline{\overline{u}}_2\right], \\
\gamma_{42}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_1' Q_0 \overline{\overline{u}}_{22} + \overline{\overline{u}}_{12}' Q_0 \overline{u}_2\right], \\
\gamma_{43}^i &= \frac{-1}{N(T-1)^{1-i}} E\left[\overline{\overline{u}}_{11}' Q_0 \overline{\overline{u}}_{22} + \overline{\overline{u}}_{12}' Q_0 \overline{\overline{u}}_{21}\right], \\
\gamma_{44}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{11}' Q_0 \overline{\overline{u}}_{21}, \\
\gamma_{45}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{12}' Q_0 \overline{\overline{u}}_{22}, \\
\gamma_{46}^i &= \frac{1}{N} tr(W_{1,N}' W_{2,N}),
\end{aligned}$$

$$\begin{aligned}
\gamma_{51}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_1' Q_0 \overline{u}_1 + \overline{\overline{u}}_{11}' Q_0 u\right], \\
\gamma_{52}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_1' Q_0 \overline{u}_2 + \overline{\overline{u}}_{12}' Q_0 u\right], \\
\gamma_{53}^i &= \frac{-1}{N(T-1)^{1-i}} E\left[\overline{\overline{u}}_{11}' Q_0 \overline{u}_2 + \overline{\overline{u}}_{12}' Q_0 \overline{u}_1\right], \\
\gamma_{54}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{11}' Q_0 \overline{u}_1, \\
\gamma_{55}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{12}' Q_0 \overline{u}_2, \\
\gamma_{56}^i &= 0,
\end{aligned}$$

$$\begin{aligned}
\gamma_{61}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_2' Q_0 \overline{u}_1 + \overline{\overline{u}}_{21}' Q_0 u\right], \\
\gamma_{62}^i &= \frac{1}{N(T-1)^{1-i}} E\left[\overline{u}_2' Q_0 \overline{u}_2 + \overline{\overline{u}}_{22}' Q_0 u\right], \\
\gamma_{63}^i &= \frac{-1}{N(T-1)^{1-i}} E\left[\overline{\overline{u}}_{21}' Q_0 \overline{u}_2 + \overline{\overline{u}}_{22}' Q_0 \overline{u}_1\right], \\
\gamma_{64}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{21}' Q_0 \overline{u}_1, \\
\gamma_{65}^i &= \frac{-1}{N(T-1)^{1-i}} E\overline{\overline{u}}_{22}' Q_0 \overline{u}_2, \\
\gamma_{66}^i &= 0,
\end{aligned}$$

$$
\begin{aligned}
\gamma_1^i &= \frac{1}{N(T-1)^{1-i}} E u' Q_0 u, \\
\gamma_2^i &= \frac{1}{N(T-1)^{1-i}} E \overline{u}_1' Q_0 \overline{u}_1, \\
\gamma_3^i &= \frac{1}{N(T-1)^{1-i}} E \overline{u}_2' Q_0 \overline{u}_2, \\
\gamma_4^i &= \frac{1}{N(T-1)^{1-i}} E \overline{u}_1' Q_0 \overline{u}_2, \\
\gamma_5^i &= \frac{1}{N(T-1)^{1-i}} E \overline{u}_1' Q_0 u, \\
\gamma_6^i &= \frac{1}{N(T-1)^{1-i}} E \overline{u}_2' Q_0 u.
\end{aligned}
$$

C Alternative Spatial Weights Matrices

The inverse distance matrix used in the analysis in this paper was constructed using a critical cut-off distance of 6,000 miles, so that all direct spatial interactions above this threshold are assumed to be negligible. The choice of cut-off distance was based on the need to allow all countries within regional trade agreements, such as the EU, NAFTA, ASEAN and MERCOSUR to be directly spatially linked.

In order to test the robustness of the results to changes in the critical cut-off distance, we estimated models (3) and (4) of Table 5.1 using spatial weights matrices with cut-off distances of 4,000 and 8,000 miles. The former captures direct spatial interactions among the EU and NAFTA countries, but not among the countries of the other regional trade agreements. The later essentially covers most direct spatial interactions, with the exception of interactions with remote countries such as Australia and New Zealand.

The estimation results for the alternative specifications of the spatial weights matrix are shown in Table 5.2. The coefficients for both the 4,000 and 8,000 miles specifications are of a similar magnitude and of the same sign as those for the 6,000 miles specification in Table 5.1. The spatial error parameters for the 4,000 miles matrix are, however, somewhat lower than those for the 6,000 and 8,000 miles matrices.

Table 2: Estimation results for alternative spatial weights matrices.

	Model (3)		Model (4)	
	4,000 miles	8,000 miles	4,000 miles	8,000 miles
Constant	-141.51^{***}	-174.15^{***}	-143.68^{***}	-119.55^{**}
	(23.31)	(58.22)	(23.93)	(60.37)
GDP (origin)	4.11^{***}	3.88^{***}	4.08^{***}	3.88^{***}
	(0.65)	(1.09)	(0.66)	(1.09)
GDP (destination)	1.23^{***}	1.39^{***}	1.47^{***}	1.63^{***}
	(0.33)	(0.36)	(0.30)	(0.33)
Distance	−1.59	−1.38	−1.60	−1.42
	(1.10)	(1.07)	(1.10)	(1.07)
Colony	0.44	0.52	0.46	0.41
	(2.41)	(2.38)	(2.46)	(2.40)
Common language	1.34	0.73	1.36	0.89
	(1.70)	(1.72)	(1.73)	(1.73)
Contiguity	−1.00	−0.67	−1.01	−0.74
	(2.63)	(2.59)	(2.68)	(2.60)
Taxes (destination)	-2.21^{*}	−1.51	−1.29	-17.51^{***}
	(1.23)	(1.34)	(1.53)	(5.47)
Education (destination)	2.88^{***}	5.12^{***}	2.89^{***}	4.81^{***}
	(0.82)	(0.85)	(0.82)	(0.85)
Econ. freedom (destination)	1.85^{**}	3.32^{***}	1.78^{**}	3.42^{***}
	(0.77)	(0.82)	(0.76)	(0.82)
Openness (destination)	−0.67	−0.29	-0.73^{*}	−0.31
	(0.41)	(0.43)	(0.40)	(0.43)
$W_2\times$ GDP	−0.20	0.98	−0.31	-1.29
	(0.38)	(1.72)	(0.44)	(1.87)
$W_2\times$ Openness	3.62^{***}	0.87	3.58^{***}	0.75
	(0.66)	(1.45)	(0.65)	(1.44)
Taxes × GDP	0.08	0.05		
	(0.05)	(0.05)		
Taxes × $W_2\times$ GDP			0.04	0.66^{***}
			(0.06)	(0.21)
ρ_1	0.13	0.21	0.12	0.21
ρ_2	0.57	0.76	0.57	0.76
σ_μ	8.24	7.66	8.17	7.70
σ_ν	8.31	7.88	8.34	7.87
Observations	8820	8820	8820	8820

Standard errors are in parentheses. * significant at 10% ** significant at 5% *** significant at 1%. All variables with the exception of Contiguity, Common Language and Colony are in logs; the interactions terms are composed of two variables in logs. The dependent variable is the log of the real FDI stock. Time dummies are included in all the regressions.

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