Distance, Trade, and FDI: A Hausman-Taylor SUR Approach

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Abstract

This paper analyzes the effects of distance as a common determinant of exports and FDI in a three factors New Trade Theory model assuming that distance affects both pure trade costs and plant set-up costs. Exports and FDI are not necessarily substitutes with respect to distance since the predicted sign depends on its importance for fixed plant set-up costs relative to transportation costs. For the empirical specification, we suggest that the impact of distance is most appropriately analyzed in a Hausman-Taylor SUR model, which allows to estimate the parameters of time-invariant variables and comes up with consistent estimation results. In our application, outward FDI is negatively affected by distance while its effect on exports is insignificantl. They are complementary with respect to the time-invariant *unobserved* factors and also with respect to the majority of the exogenous *observed* determinants.

Key words: Multinationals; New trade theory; Panel econometrics

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1 Introduction

The role of transport costs has become one of the most deeply analyzed topics in theoretical and empirical economics of international trade, with the gravity model of trade as the most prominent example. In the late eighties, the New Trade Theory and more recently also the endowment-based models of trade and multinationals suggest gravity models for the analysis of both trade and FDI. In these models both the bilateral volume of trade and multinational activity (in terms of foreign affiliate sales or FDI) are determined by the same explanatory factors constituting the proximity-concentration trade-off: (relative and absolute) factor endowments, fixed costs of setting up a foreign plant, and transportation costs. From this perspective, one expects a negative impact of transportation costs on trade and a positive one on multinational activity (FDI). Hence, outward FDI and exports are substitutes with respect to transportation costs.

In the empirical literature on bilateral trade and FDI distance is the most frequently used proxy of transportation costs and known for its robust negative impact on both.[1] However, the proximity-concentration trade-off suggests a positive impact of trade costs on FDI, and the association of distance with pure trade costs is questionable from this point of view. The empirical analysis of the determinants of bilateral multinational sales and FDI has mainly built on the above mentioned proximity-concentration trade-off models. But implicitly, most traditional gravity models assume a relation between distance and pure trade costs alone, ignoring its direct relevance for MNE activity as well. If distance has an impact on both, the theoretically expected effect on exports and outward FDI is ambiguous.

We model distance as an impediment to both trade and FDI. Our theoretical model of trade and multinationals assumes that the impact of distance depends on its relative importance for fixed plant set-up costs versus pure trade costs. The

[1] Examples for gravity models on trade are Bergstrand (1985, 1989) and Wang & Winters (1991). Gravity models on FDI (affiliate sales) have been estimated by Markusen & Maskus (1999) and Carr et al. (2001). Graham (1996) and Brenton et al. (1999) analyze the relationship between exports and FDI running gravity regressions on both.

simulations indicate that exports and outward FDI may either be substitutive or complementary with respect to distance. From an econometric point of view, the presence of common determinants like distance requests an adequate bivariate specification, which so far has not been presented. We suggest a seemingly unrelated regression (SUR) framework, which explicitly accounts for the common determinants and which is more efficient. Specifically, we set-up a SUR Hausman-Taylor model (HTM-SUR), which has not been used previously. Controlling for bilateral (random) heterogeneity of export and outward FDI relationships, this model provides parameter estimates of time-invariant variables such as distance. In contrast to the traditional random effects model, it also eliminates the bias in parameter estimates stemming from endogenous unobserved effects.

Our empirical results are widely in accordance with the theoretical model. Controlling for bilateral random effects, we find that distance significantly reduces bilateral outward FDI, whereas its effect on exports insignificant. Moreover, the correlation of the random effects indicates a significant complementary relationship between exports and outward FDI with respect to the common, unobserved, time-invariant, bilateral determinants.

The paper proceeds as follows. The next section sets out the theoretical hypotheses providing simulations of a three-factors model on trade and MNE activity. Section 3 presents the econometric model and discusses the HTM-SUR approach. Section 4 summarizes the estimation results and the last section concludes.

2 Theoretical Background

We base the theoretical set-up on a three-factors model and introduce distance as a determinant of both trade costs and plant set-up costs at a possibly different intensity. The demand side comprises a single, horizontally differentiated good which is produced either by foreign or domestic exporters or MNEs. In general, the horizontal MNEs do not engage in goods trade and both exporters and MNEs serve their home market with home production. In contrast to Markusen & Venables (2000), MNEs are not footloose, rather they are headquartered in one country where they also run a plant to serve the domestic market. Both location and the scope of activity of firms are endogenously determined resulting in a simultaneous two-way exports and outward FDI pattern for a large subset in the endowment space.[2]

Factor markets: Both exports and outward FDI depend on factor endowments, trade costs and fixed costs of setting up a plant abroad. Three factors (low-skilled labor, L, high-skilled labor, H, and physical capital, K) are used in goods production. Without any loss of generality we assume that invention of a blueprint necessitates only H as an input, and plant set-up requires K exclusively. For simplicity, we rescale the input coefficients for both the invention of blueprints and for plant set-up to one.

In the following, n_i (m_i) refers to the number of exporters (MNEs) located in country i. x_{ii} is the production for a firm's home market, whereas x_{ij} denotes a firm's exports from country i to j. Similar to Markusen & Venables (2000), x_{ij} includes iceberg trade costs. Factor market clearing requires:

$$\begin{aligned} L_i &= a_{Lx}(\mathbf{w_i})[(n_i + m_i + m_j)x_{ii} + n_i x_{ij}] \\ H_i &= a_{Hx}(\mathbf{w_i})[(n_i + m_i + m_j)x_{ii} + n_i x_{ij}] + n_i + m_i \\ K_i &= a_{Kx}(\mathbf{w_i})[(n_i + m_i + m_j)x_{ii} + n_i x_{ij}] + n_i + (2+\gamma)\, m_i, \end{aligned} \tag{1}$$

where $a_{Lx}(\mathbf{w_i})$, $a_{Hx}(\mathbf{w_i})$, and $a_{Kx}(\mathbf{w_i})$, are input coefficients for the production of one unit of output, all depending on the vector of domestic factor rewards ($\mathbf{w_i}$).[3] To capture our main hypothesis, we assume that distance (δ) simultaneously increases pure trade costs (t) and set-up costs for a foreign plant ($1+\gamma$). We define trade costs as country-specific iceberg transportation costs ($t = t_0+\delta$). Setting up a second plant abroad requires higher fixed costs than operating a domestic plant and serving the

[2] Note that in Markusen & Venables (1998, 2000) mixed equilibria only exist for knife-edge cases or very small and implausible subsets of the endowment space.

[3] Note that there are restrictions on the factor endowments in order to come up with positive factor rewards and a mixed equilibrium with both $m_i, m_j, n_i, n_j > 0$ (see Egger & Pfaffermayr, 2000).

foreign country via exports ($\gamma = \gamma_0 + \rho\delta$). Similar to trade costs, plant set-up costs are iceberg costs, where $\rho\delta$ measures the amount of physical capital, which is lost in the case of setting up a foreign affiliate. We assume that distance increases this cost (e.g. because of differences in the cultural, political or the economic environment, etc.). In any case, a MNE has to send $\gamma_0 + \rho\delta$ units of capital in order to provide γ_0 units of capital, which are necessary to set-up production facilities abroad.

Demand side: Formally and as usual, demand is derived from a CES Dixit & Stiglitz (1977) utility function:

$$x_{ii} = p_{ii}^{-\varepsilon} s_i^{\varepsilon-1} E_i \qquad ; \qquad x_{ij} = p_{ii}^{-\varepsilon} t_j^{1-\varepsilon} s_j^{\varepsilon-1} E_j \tag{2}$$

where ε is the elasticity of substitution, E_i denotes domestic factor income and s_i is the price aggregator defined as (see Markusen & Venables, 2000)

$$s_i = [(n_i + m_i + m_j) p_{ii}^{1-\varepsilon} + n_j (t_i p_{jj})^{1-\varepsilon}]^{1/(1-\varepsilon)}. \tag{3}$$

According to our empirical measurement of exports and outward FDI we focus on real figures. In particular, we measure country i's real exports by $n_i x_{ij}$. Empirically, this corresponds to the shipment of exports at f.o.b., which is most closely related to the production of goods for export. In contrast, the stock of FDI excludes the capital lost due to distance in (or before) the process of setting up the foreign plant. Consequently, country i's real outward FDI is defined as $m_i(1 + \gamma_0)$.

Zero profit conditions: Free entry results in zero profits for both exporters (superscript x) and MNEs (superscript m):

$$\begin{aligned} \pi_i^x &= p_{ii} x_{ii} + p_{ii} x_{ij} - w_{Li} x_{ii} - w_{Li} x_{ij} - w_{Hi} - w_{Ki} \\ \pi_i^m &= p_{ii} y_{ii} + p_{jj} y_{ij} - w_{Li} y_{ii} - w_{Lj} y_{ij} - w_{Hi} - (2+\gamma)\, w_{Ki} \end{aligned} \tag{4}$$

Implicitly, these two conditions represent the proximity-concentration trade-off for given factor rewards.

Balance of Payments: The balance of payments guarantees that goods trade flows are balanced by both trade in invisibles and capital flows across borders, which we interpret as FDI. Headquarter services and FDI do not enter the balance of payments separately. Rather the sum of the two is included, which corresponds to the profits of the affiliates of the MNEs.

$$n_i p_{ii} x_{ij} + (1-\theta) p_{jj} x_{jj} m_i = n_j p_{jj} x_{ji} + (1-\theta) p_{ii} x_{ii} m_j. \tag{5}$$

Simulation results: The above model cannot be solved analytically due to the nonlinearities induced by iceberg transportation costs. Hence, we solve the model numerically for particular parameter values considering only interior solutions (see the Appendix for more details).

> Table 1 <

Table 1 summarizes the results of comparative static analysis of real exports and outward FDI with respect to changes in the exogenous determinants of the empirical gravity model below. The bilateral sum of GDP (a proxy for the size of the bilateral economic factor space: $G = GDP_i + GDP_j$) and the similarity of country size measured in terms of GDP ($S = 1-(GDP_i/G)^2-(GDP_j/G)^2$) exhibits the same positive impact as in other New Trade Theory gravity models for trade (see Helpman & Krugman, 1985, Helpman, 1987, Bergstrand, 1990, etc.). The present model suggests that FDI does not depend on the similarity of country size, rather it is positively related to relative country size measured by $g = GDP_i/GDP_j$. The reason lies in the absence of the home market bias for MNE sales (and therefore FDI) at a given distance.

Outward FDI and exports are substitutive with respect to changes in the relative endowment with physical capital ($k = K_i/K_j$). A larger endowment in K_i c.p. increases the number of country i's MNEs and its FDI, resulting in a reduction in the number of exporters and also of aggregate exports. Outward FDI and exports are complementary with respect to changes in relative human capital endowments ($h = H_i/H_j$). An increase in h increases a country's comparative advantage in brand invention. According to the Dixit & Stiglitz (1977) love-for-variety preferences, the home market bias associated with transport costs is less pronounced for a high degree of product diversity, so that exports *and* outward FDI increase simultaneously with h. In contrast, a rise in $l = L_i/L_j$ generates a comparative advantage in goods production, which increases real exports but reduces real outward FDI.

> Figure 1 <

The impact of distance on exports and outward FDI depends on the parameter ρ, which tells us how important distance is for fixed plant set-up costs relative to trade costs (see also Figure 1). An increase in ρ implies that distance affects plant set-up costs more severely. Consequently, exports are falling and outward FDI is rising with distance at low values of ρ. For medium ρ, distance exhibits a negative impact on both exports and outward FDI, and if ρ is sufficiently high, the relationship again changes to a substitutive one with exports increasing and outward FDI falling. Hence, the impact of distance on exports and FDI is an empirical issue, which is investigated below.

3 Econometric Model

The theoretical model suggests that (outward) FDI is determined by bilateral overall country size (G), relative country size (g), relative factor endowments (k, h, l), and distance (D), which measures both country-specific transport costs and fixed foreign plant set-up costs. Additionally, exporter and importer specific viability of contracts (V) and rule of law (R) enter the econometric model proxying other aspects of trade costs and FDI costs, which are unaffected by distance. Noteworthy, exports are determined by the same factors, but in contrast to FDI they are a function of similarity in country size (S) but not of g.

Formally, we specify a system of two equations (exports and outward FDI) with fixed time effects (λ_t^E, λ_t^F) and bilateral effects (μ_{ij}^E, μ_{ij}^F), the latter capturing all unobserved determinants of bilateral trade and FDI, respectively. Given the large number of bilateral relations, we treat the bilateral effects as random, which - in contrast to a fixed effects framework - allows to estimate the parameter of the time-invariant distance variable.[4]

$$
\begin{aligned}
E_{ijt} = {} & \beta_0^E + \gamma_1^E D_{ij} + \beta_1^E G_{ijt} + \beta_2^E S_{ijt} + \beta_3^E k_{ijt} + \beta_4^E h_{ijt} + \beta_5^E l_{ijt} \\
& + \beta_6^E V_{it} + \beta_7^E V_{jt} + \beta_8^E R_{it} + \beta_8^E R_{jt} + \lambda_t^E + u_{ijt}^E
\end{aligned}
\tag{6}
$$

$$
\begin{aligned}
F_{ijt} = {} & \beta_0^F + \gamma_1^F D_{ij} + \beta_1^F G_{ijt} + \beta_2^F g_{ijt} + \beta_3^F K_{ijt} + \beta_4^F H_{ijt} + \beta_5^F L_{ijt} \\
& + \beta_6^F V_{it} + \beta_7^F V_{jt} + \beta_8^F R_{it} + \beta_9^F R_{jt} + \lambda_t^F + u_{ijt}^F
\end{aligned}
\tag{7}
$$

with $u_{ijt}^E = \mu_{ij}^E + \varepsilon_{ijt}^E$ and $u_{ijt}^F = \mu_{ij}^F + \varepsilon_{ijt}^F$. Following Baltagi's (1995) notation, the random effects are distributed according to $\mu \sim N(0, \Sigma_\mu)$, and the remainder error $\varepsilon \sim N(0, \Sigma_\varepsilon)$. μ and ε are $(NT \times 2)$ column vectors with

$$
E \begin{pmatrix} \mu^j \\ \varepsilon^j \end{pmatrix} \begin{pmatrix} (\mu^l)' & (\varepsilon^l)' \end{pmatrix} = \begin{bmatrix} \sigma_{\mu^{jl}}^2 I_N & 0 \\ 0 & \sigma_{\varepsilon^{jl}}^2 I_{NT} \end{bmatrix}, \quad j, l = E, F. \tag{8}
$$

N is the number of bilateral relations and NT denotes the total number of observations. $\Sigma_\mu = \left[\sigma_{\mu^{jl}}^2\right]$ is the variance covariance matrix corresponding to the cross-sectional, bilateral unobserved effects, whereas $\Sigma_\varepsilon = \left[\sigma_{\varepsilon^{jl}}^2\right]$ is the variance covariance matrix of the error term. Each error component fulfills the standard Zellner (1962) assumption. For estimation, one has to transform the system of equations by premultiplying it with (see Baltagi, 1980)

$$
\Omega^{-1/2} = \Sigma_1^{-1/2} \otimes P + \Sigma_\varepsilon^{-1/2} \otimes Q. \tag{9}
$$

$P = I_N \otimes J_T/T$, $Q = I_{NT} - P$, I_N and I_{NT} denote identity matrices of dimension N and NT, respectively, and J_T is a $T \times T$ matrix of ones.[5] Σ_1 is the usual combined error term (see Baltagi, 1995). In this way one obtains homoskedastic and independent errors, so that the transformed model can be estimated by OLS (REM-SUR). Following Amemiya (1971), we estimate the variance components Σ_1

[4] The fixed effects estimator wipes out all time-invariant variation.

[5] This holds only true for balanced panel data, but it simply generalizes to the unbalanced case, which is relevant in our application.

by $U'PU/N$ and Σ_ε by $U'QU/N(T-1)$, where U denotes the $NT \times 2$ matrix of the Within-type residuals.

The standard random effects model (REM), the REM-SUR model requires that the right hand side variables are independent of the unobserved bilateral effects. If this condition is violated (which can be tested by the familiar Hausman test, 1978), an endogeneity problem emerges, rendering the traditional REM or REM-SUR estimates inconsistent. In order to obtain consistent parameter estimates for both the time-variant variables and especially for the time-invariant distance, we follow Hausman & Taylor (1981) and Cornwell et al. (1992)[6] and use the various dimensions of variation in the panel for the construction of proper instruments and estimate the model by 2SLS to overcome this endogeneity problem. Thereby, one has to distinguish between variables, which are not correlated with the unobserved effects (*doubly exogenous* variables) and variables which are correlated with the unobserved effects (*singly exogenous* variables).[7]

The matrix of time-variant explanatory variables consists of 2 subsets: $X = [X_1, X_2]$, X_1 is assumed to be *doubly exogenous*, and X_2 is *singly exogenous* (i.e. correlated with μ_{ij}). Time-invariant distance (D) is likewise assumed to be *singly exogenous*. There is no way to decide a priori which group an explanatory variable belongs to. Rather, this has to be done on the grounds of plausible a priori hypotheses and checked in a sensitivity analysis. The appropriateness of the decision can be tested by an over-identification test in the spirit of Hausman & Taylor (1981). D is very likely *singly exogenous*, since in the present specification, the random bilateral effects reflect time-invariant bilateral propensity to export (to invest abroad) like geographic and cultural proximity, etc., which are partly correlated also with distance between any two countries. Additionally, variables correlated with babsolute ilateral size like G are likely *singly exogenous*. Moreover, in our application it turned out that relative endowments (k, h, l) should also be treated as *singly exogenous*. Interestingly, we find that the relative country size (g) and the similarity index for

[6]The latter explicitly refer to the estimation of simultaneous equations with panel data.

[7]We do not consider the problem of endogeneity in the sense that an explanatory variable is correlated with the remainder error term (ε).

country size (S) do not face this correlation problem. The main advantage of the Cornwell et al. (1992) approach is the possible isolation of the effect of D from the other time-invariant unobserved effects, which is impossible in a fixed effects framework.

The correlation of the error components of the two equations (exports and outward FDI) has a useful economic interpretation. Using a cross-sectional gravity model, Graham (1996) argues that the correlation of the residuals from a FDI and an exports regression reflects their interrelationship with respect to unobserved determinants after controlling for common exogenous influences.[8] This can be done more appropriately with the present set-up. The off-diagonal elements of Σ_μ (i.e. $\sigma^2_{\mu^{jl}}$ for $i \neq l$) form a natural measure of substitution/complementarity with respect to unobserved constant effects. Deriving this relationship from the residuals of simple OLS cross-section regressions involves an important problem. Bilateral trade data exhibit a two-way panel structure in each year (exporter and importer country effects), which is not removed by averaging over time. Hence, ignoring exporter and importer heterogeneity creates an endogeneity problem as the explanatory variables (like GDP) are likely to be correlated with these effects leading to inconsistent estimates as suggested by Hausman & Taylor (1981) and maybe to wrong conclusions concerning complementarity/substitution between exports and outward FDI.[9] Therefore, whenever such a correlation is present, the proposed Hausman-Taylor SUR panel data approach (HTM-SUR) is the most appropriate one.

4 Data and Estimation Results

We run regressions on bilateral exports and outward stocks of FDI from OECD countries to other economies (including OECD and non-OECD countries) covering the

[8] Of course, complementarity/substitution can also be analyzed with respect to changes in common exogenous determinants. Complementarity would then be associated with identical signs in the respective coefficient in the two equations.

[9] This problem gets even more severe, when the residual of one of the two equations is used as an explanatory variable in the other one (compare Brenton et al., 1999).

period 1986-1997. Nominal exports in current USD (from OECD, Monthly Statistics of International Trade; IMF, Direction of Foreign Trade; and the Vienna Institute of International Economic Studies, hereafter WIIW) are converted by export price (IMF, International Financial Statistics; OECD, Economic Outlook; and WIIW) and exchange rate indices (IMF, International Financial Statistics; and WIIW) to obtain real values with 1995 as the base year. Outward FDI stock data in current prices and dollars were taken from the OECD International Direct Investment Statistics Yearbook. We consider the reported book values of foreign assets as a rough approximation of depreciated initial values and convert them to real values by the use of investment deflators (OECD National Accounts, Volume 1) in combination with the exchange rate indices for all countries, in order to arrive at a proxy for real stocks of bilateral outward FDI. Nominal GDP in USD (OECD, Economic Outlook and National Accounts Volume 1; IMF, International Financial Statistics; and WIIW) are also converted to real numbers using GDP deflators (same sources as GDP) and exchange rate indices. Population numbers are collected from OECD (Economic Outlook and National Accounts Volume 1), IMF (International Financial Statistics) and WIIW.

The relation between exporter and importer endowment with low-skilled workers (l_{ijt}) is approximated by the relation of people with only primary education. The exporter-to-importer relation in the endowment with human capital (h_{ijt}) is approximated by the respective ratio of the sum of persons with secondary and tertiary school enrolment (OECD Education Statistics 1985-1992, Education at a Glance, several years, and the UNESCO Statistical Yearbook). Capital stocks are estimated by the perpetual inventory method assuming the initial period's (1978) capital stock as

$$K_{1978} = 2 \cdot (I_{1976} + I_{1977} + I_{1978} + I_{1979} + I_{1980}) \tag{10}$$

where I_t is the gross fixed capital formation. Additionally, we assume a constant and identical depreciation rate of 7 percent in order to come up with real capital stocks in the other years as

$$K_t = 0.93 \cdot K_{t-1} + I_t \tag{11}$$

Two economic freedom variables are included for the exporters and the importers each, which are provided by Economic Freedom Network (Economic Freedom of the World) and account for legal structure and property rights (Area V of the database) and international exchange (part of Area VI of the respective database). These variables are based on (zero-to-ten) ratings and can be interpreted as export and FDI impeding or enforcing determinants other than distance. The corresponding variables are viability of contracts (V_{it}, V_{jt}), and rule of law (R_{it}, R_{jt}).

All variables are in logs. The panel covers the period 1986 to 1997 and is unbalanced, mainly due to the availability of bilateral data on FDI. After removing all bilateral relations with less than three observations over time, we come up with 1682 observations.

> Table 2 <

Table 2 presents the regression results for the three different panel estimators on both the export and the FDI equation. In all specifications time effects are significant. Specifications E1 and F1 show the consistent but inefficient Within estimator results, which do not provide a parameter estimate for distance. In accordance with New Trade theory and the above model, bilateral exports increase with bilateral sum of GDP (G) and similarity in terms of GDP (S), whereas bilateral stocks of outward FDI are an increasing function of G and relative GDP (g). Exports and outward FDI are complements with respect to changes in relative human capital endowments (h). In contrast to theory the impact is negative, indicating that enrolment figures are possibly only weak proxies for human capital. In line with the model, exports and outward FDI are substitutes with respect to a change in the endowment with low-skilled labor. This is also consistent with the vertical model of FDI in the spirit of Helpman (1984).[10] Interestingly, a change of the economic freedom variables,

[10]In contrast to the horizontal model, the vertical set-up allows for a full separation of headquarter services from production facilities.

which can be interpreted as cost measures of international economic relations in a broad sense (affecting both transport costs and plant set-up costs independently of distance), does not exhibit a unified impact: exporter viability of contracts affects exports negatively exports whereas the other freedom variables exert a positive impact on exports, but neither of them exhibits a significant influence on outward FDI.

In order to obtain an estimate of the distance variable, we first run a traditional Hausman-Taylor (1981) model (HTM) treating D, G, h k, and l as *singly exogenous* (i.e. correlated with the unobserved effects) and the remaining ones as *doubly exogenous* variables.[11] Distance exerts a significant negative impact on outward FDI, whereas in our application the impact on exports is much smaller in absolute terms and could not be estimated precisely.

The HTM is successful in terms of both the test for over-identification and the canonical correlations. The former indicates that this approach provides consistent and more efficient estimates since the difference to the Within model is too narrow in order to reject the HTM. The latter is the geometric mean of the canonical correlations measuring the average correlation between the set of instruments and the endogenous variables (see Bowden & Turkington, 1986, and Baltagi & Khanti-Akom, 1990). Compared to the overall fit, the set of instruments seems highly relevant, yielding average correlation coefficients of 0.61 in specification E2 and 0.67 in specification F2.

The HTM-SUR additionally accounts for the correlation of the error components and is even closer to the consistent Within model than the traditional HTM. It additionally allows to estimate the parameters more efficiently. The corresponding error component matrix estimates are

$$\widehat{\Sigma}_{\mu} = \begin{bmatrix} 1.4245 & 2.9112 \\ 2.9112 & 12.5990 \end{bmatrix}; \quad \widehat{\Sigma}_{\varepsilon} = \begin{bmatrix} .0227 & .0021 \\ .0021 & .2256 \end{bmatrix} \tag{12}$$

[11] As indicated by the Hausman test, the REM is rejected and there is no way to obtain consistent GLS estimates for both the time-variant variables and distance.

The off-diagonal element of $\widehat{\Sigma}_\mu$ in (12) represents an estimate of the covariance between the random bilateral exporter and FDI effects. The positive sign indicates a complementary relationship between the two after controlling for common and observed exogenous determinants. The corresponding correlation coefficient amounts to 0.69. The correlation between the remainder errors is of negligible size (0.03). The respective correlation coefficient of the $\widehat{\Sigma}_1$ matrix, which combines both components, is highly significant following a Honda test.[12] The test statistic is 33.82 and follows a standard normal distribution. Hence, the simple HTM (E2, F2) is rejected in favor of the HTM-SUR (E3, F3).

5 Conclusions

This paper analyzes the impact of distance on both bilateral exports and outward FDI. In a three-factors proximity-concentration set-up of trade and MNE activity, our simulations indicate that distance affects both exports and outward FDI in a non-trivial way. However, if distance is extremely important for plant set-up costs, it may also increase exports. In the general equilibrium context, the direct negative effect on exports may be outweighed by an indirect one induced by the pronounced reduction of stocks of outward FDI. Hence, the overall effect remains an empirical question, and exports and outward FDI could be either substitutes or complements with respect to distance depending on its importance for the two.

Empirically, we suggest a methodology of analyzing the relationship between exports and stocks of outward FDI, which is different from previous research. According to the recent theory on trade and MNEs, exports and FDI face common determinants. We therefore use a Hausman-Taylor SUR set-up. This allows to simultaneously control for the influence of common exogenous determinants and estimate the direct relationship between exports and outward FDI in terms of un-

[12] This test is based on the square root of the familiar Breusch-Pagan test on the hypothesis that the cross-equation correlation is zero (see Baltagi, 1995, p. 62 and p. 104, and Greene, 1993, p. 493).

observed, time-invariant bilateral effects. This approach gives consistent parameter estimates and is superior to the corresponding fixed effects model. Especially, it yields parameter estimates for time-invariant variables such as distance when controlling for bilateral heterogeneity. Our estimation results are widely in accordance with the theoretical hypotheses. In particular, we find that distance exerts a significant, negative impact on bilateral stocks of outward FDI, whereas the effect on exports is insignificant. Moreover, exports and outward FDI are complementary with respect to the unobserved time-invariant determinants.

6 References

Amemiya, Takeshi (1971), The Estimation of the Variances in a Variance-Components Model, *International Economic Review* 12, pp. 1-13.

Baltagi, Badi H. (1980), On Seemingly Unrelated Regressions With Error Components, *Econometrica* 48, pp. 1547-1551.

Baltagi, Badi H. (1995), *Econometric Analysis of Panel Data* (Chichester: Wiley).

Baltagi, Badi H., and Sophon Khanti-Akom (1990), On Efficient Estimation with Panel Data: An Empirical Comparison of Instrumental Variables Estimators, *Journal of Applied Econometrics* 5, pp. 401-406.

Bergstrand, Jeffrey H. (1985), The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence, *Review of Economics and Statistics* 67, pp. 474-481.

Bergstrand, Jeffrey H. (1989), The Generalized Gravity Equation, Monopolistic Competition, and Factor Proportions Theory in International Trade, *Review of Economics and Statistics* 71, pp. 143-153.

Bergstrand, Jeffrey H. (1990), The Heckscher-Ohlin-Samuelson Model, The Linder Hypothesis and the Determinants of Bilateral Intra-Industry Trade, *Economic Journal* 100, pp. 1216-1229.

Bowden, Roger J., and Darrell A. Turkington (1986), *Instrumental Variables* (Cambridge: Cambridge University Press).

Brenton, Paul, Francesca Di Mauro, and Matthias Lücke (1999), Economic Integration and FDI: An Empirical Analysis of Foreign Investment in the EU and in Central and Eastern Europe, *Empirica* 26(2), pp. 95-121.

Carr, David, James R. Markusen, and Keith E. Maskus (2001), Estimating the Knowledge-Capital Model of the Multinational Enterprise, *American Economic Review*, forthcoming.

Cornwell, Christopher, Peter Schmidt, and Donald J. Wyhowski (1992), Simultaneous Equations and Panel Data, *Journal of Econometrics* 51, pp. 151-181.

Dixit, Avinash K., and Joseph E. Stiglitz (1977), Monopolistic Competition and Optimum Product Diversity, *American Economic Review* 67, pp. 297-308.

Egger, Peter, and Michael Pfaffermayr (2000), Trade, Multinational Sales and FDI in a Three-Factors Model, University of Linz Working Paper No. 0013.

Graham, Edward M. (1997), US Direct Investment Abroad and US Exports in the Manufacturing Sector: Some Empirical Results Based on Cross-Sectional Analysis, in: Buckley, Peter J., and Jean-Louis Mucchielli (eds.), Multinational Firms and International Relocation, New Horizons in International Business series (Cheltenham, U.K. and Lyme, N.H: Elgar), pp. 90-102.

Greene, William H. (1993), *Econometric Analysis* (New Jersey: Prentice Hall).

Hausman, Jerry A. (1978), Specification Tests in Econometrics, *Econometrica* 46, pp. 1251-1271.

Hausman, Jerry A., and William E. Taylor (1981), Panel Data and Unobservable Individual Effects, *Econometrica* 49, pp. 1377-1398.

Helpman, Elhanan, (1984), A Simple Theory of International Trade with Multinational Corporations, *Journal of Political Economy* 92, pp. 451-472.

Helpman, Elhanan, (1987), Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries, *Journal of the Japanese and International Economies* 1, pp. 62-81.

Helpman, Elhanan, and Paul R. Krugman (1985), *Market Structure and Foreign Trade* (Cambridge, Mass.: MIT Press).

Markusen, James R., and Keith E. Maskus (1999), Multinational Firms: Reconciling Theory and Evidence, NBER Working Paper No. 7163.

Markusen, James R., and Anthony J. Venables (1998), Multinational Firms and the New Trade Theory, *Journal of International Economics* 46, pp. 183-203.

Markusen, James R., and Anthony J. Venables (2000), The Theory of Endowment, Intra-Industry, and Multinational Trade, *Journal of International Economics* 52, pp. 209-234.

Wang, Zhen K., and Alan L. Winters (1991), The Trading Potential of Eastern

Europe, CEPR Discussion Paper No. 610.

Zellner, Arnold (1962), An Efficient Method of Estimating Seemingly Unrelated Regression and Tests for Aggregation Bias, *Journal of the American Statistical Association* 57, pp. 348-368.

7 Appendix: Simulation Details

For simplicity, we use a Cobb-Douglas technology for goods production to derive the input coefficients:

$$\begin{aligned} a_{Lxi}(\mathbf{w}) &= \left(\frac{w_{Hi}}{w_{Li}}\frac{a}{b}\right)^b \left(\frac{w_{Ki}}{w_{Li}}\frac{a}{c}\right)^c \\ a_{Hxi}(\mathbf{w}) &= \left(\frac{w_{Li}}{w_{Hi}}\frac{b}{a}\right)^a \left(\frac{w_{Ki}}{w_{Hi}}\frac{b}{c}\right)^c \\ a_{Kxi}(\mathbf{w}) &= \left(\frac{w_{Li}}{w_{Ki}}\frac{c}{a}\right)^a \left(\frac{w_{Hi}}{w_{Ki}}\frac{c}{b}\right)^b \end{aligned} \tag{13}$$

and similarly for country j assuming constant returns to scale ($a+b+c=1$) and identical technology parameters across countries. We define unit costs by

$$\begin{aligned} d_i &= a_{Lxi}w_{Li} + a_{Hxi}w_{Hi} + a_{Kxi}w_{Ki} \\ d_j &= a_{Lxj}w_{Lj} + a_{Hxj}w_{Hj} + a_{Kxj}w_{Kj}, \end{aligned} \tag{14}$$

set $w_{Lj} = 1$ and simulate the following 11 conditions in order to derive results for the remaining 11 variables (w_{Li}, w_{Ki}, w_{Kj}, w_{Hi}, w_{Hi}, x_{ii}, x_{jj}, n_i, n_j, m_i, m_j):

$$\frac{L_i}{a_{Lxi}} - (n_i + m_i + m_j)x_{ii} - n_i x_{jj} t^{1-\varepsilon} \left(\frac{d_i}{d_j}\right)^{-\varepsilon} = 0 \tag{15}$$

$$\frac{L_j}{a_{Lxj}} - (n_j + m_i + m_j)x_{jj} - n_j x_{ii} t^{1-\varepsilon} \left(\frac{d_i}{d_j}\right)^{\varepsilon} = 0 \tag{16}$$

$$H_i - \frac{a_{Hxi} L_i}{a_{Lxi}} - n_i - m_i = 0 \tag{17}$$

$$H_j - \frac{a_{Hxj} L_j}{a_{Lxj}} - n_j - m_j = 0 \tag{18}$$

$$K_i - \frac{a_{Kxi} L_i}{a_{Lxi}} - n_i - (2+\gamma)m_i = 0 \tag{19}$$

$$K_j - \frac{a_{Kxj} L_j}{a_{Lxj}} - n_j - (2+\gamma)m_j = 0 \tag{20}$$

$$x_{ii} + x_{jj} t^{1-\varepsilon} \left(\frac{d_i}{d_j}\right)^{-\varepsilon} - \frac{(\varepsilon - 1)(w_{Hi} + w_{Ki})}{d_i} = 0 \tag{21}$$

$$x_{jj} + x_{ii} t^{1-\varepsilon} \left(\frac{d_i}{d_j}\right)^{\varepsilon} - \frac{(\varepsilon - 1)(w_{Hj} + w_{Kj})}{d_j} = 0 \tag{22}$$

$$x_{ii} + x_{jj} \frac{d_i}{d_j} - \frac{(\varepsilon - 1)(w_{Hi} + (2+\gamma) w_{Ki})}{d_i} = 0 \tag{23}$$

$$x_{jj} + x_{ii} \frac{d_i}{d_j} - \frac{(\varepsilon - 1)(w_{Hj} + (2+\gamma) w_{Kj})}{d_j} = 0 \tag{24}$$

$$x_{jj}\left(n_i t^{1-\varepsilon}\left(\frac{d_i}{d_j}\right)^{1-\varepsilon} + \frac{m_i}{\varepsilon}\right) - x_{ii}\left(n_j t^{1-\varepsilon}\left(\frac{d_i}{d_j}\right)^{\varepsilon} + \frac{d_i}{d_j}\frac{m_j}{\varepsilon}\right) = 0 \tag{25}$$

For our simulations, we set the world endowments (labelled by "$\sim$") at $\widetilde{L} = 100$, $\widetilde{H} = 120$, and $\widetilde{K} = 250$. For the Cobb-Douglas coefficients we assume $a = 0.6$, $b = 0.01$, $c = 0.39$ without any loss of generality. Moreover, $\varepsilon = 2$, $t_0 = 1.13$, $\gamma_0 = 0.5$, $0 \leq \delta \leq 0.024$ and $1 \leq \rho \leq 25$.

Figure 1a: Exports and a Change in Distance

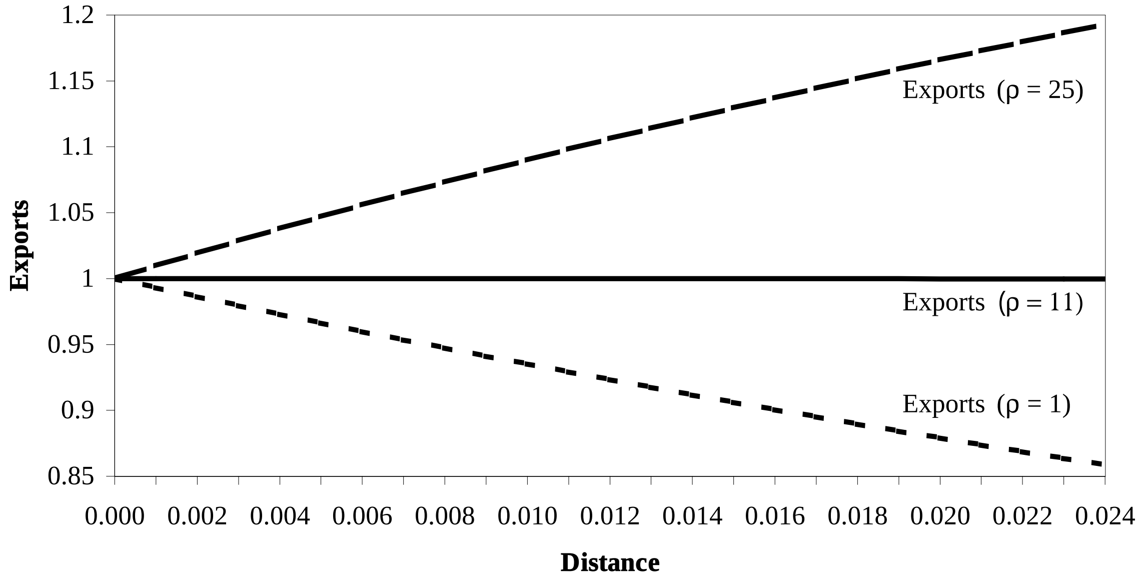

Figure 1b: Outward FDI and a Change in Distance

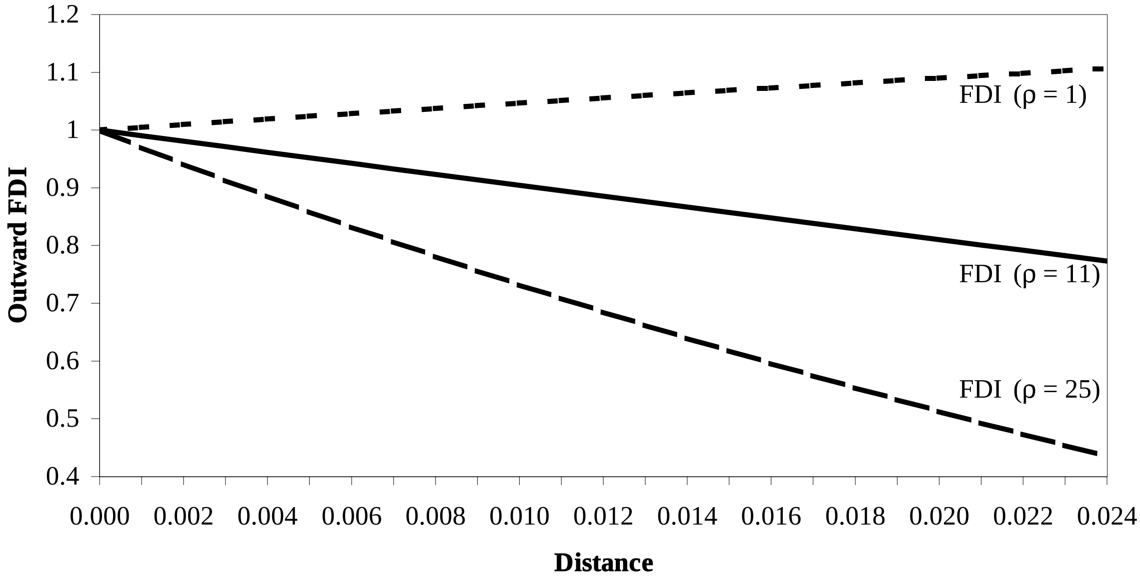

Table 1: The Comparative Statics for Exports and FDI

	Exports (E)	FDI (F)
Relative bilateral GDP		+
Sum of bilateral GDP	+	+
Similarity in country size	+	
Relative physical capital endowment	-	+
Relative human capital endowment	+	+
Relative labor endowment	+	-
Distance:		
high ρ	+	-
medium ρ	-	-
low ρ	-	+

Table 2: Panel Regression Results for Bilateral Exports (Real Figures and Variables in Logs)

	Real bilateral exports			Real bilateral stocks of outward FDI		
	Within	Hausman-Taylor	Hausman-Taylor SUR	Within	Hausman-Taylor	Hausman-Taylor SUR
Independent Variables[1)]						
Distance	-	-0.234	-0.033	-	-2.386 ***)	-4.309 ***)
	-	(0.205)	(0.202)	-	(0.511)	(1.349)
Relative bilateral GDP	-	-	-	0.834 **)	0.853 ***)	1.026 ***)
	-	-	-	0.334	0.291	0.300
Sum of bilateral GDP	2.533 ***)	2.340 ***)	1.998 ***)	4.481 ***)	4.166 ***)	4.547 ***)
	(0.199)	(0.151)	(0.154)	(0.608)	(0.531)	(0.575)
Similarity in country size	0.783 ***)	1.107 ***)	1.017 ***)	-	-	-
	(0.127)	(0.107)	(0.109)	-	-	-
Relative physical capital endowment	-0.237 ***)	-0.298 ***)	-0.204 ***)	0.066	0.005	0.158
	(0.084)	(0.082)	(0.073)	(0.300)	(0.278)	(0.281)
Relative human capital endowment	-0.106 **)	-0.126 **)	-0.115 **)	-0.736 ***)	-0.671 ***)	-0.705 ***)
	(0.052)	(0.053)	(0.053)	(0.165)	(0.155)	(0.156)
Relative labor endowment	0.193 ***)	0.175 ***)	0.151 ***)	-0.397 ***)	-0.309 **)	-0.342 ***)
	(0.046)	(0.045)	(0.045)	(0.146)	(0.124)	(0.131)
Exporter viability of contracts	-0.248 **)	-0.316 ***)	-0.199 **)	-0.098	-0.020	-0.116
	(0.098)	(0.106)	(0.101)	(0.312)	(0.304)	(0.303)
Importer viability of contracts	0.391 ***)	0.049	0.387 ***)	-0.125	-0.066	-0.104
	(0.073)	(0.033)	(0.074)	(0.234)	(0.228)	(0.227)
Exporter rule of law	0.168 **)	0.232 ***)	0.190 ***)	0.123	0.165	0.067
	(0.075)	(0.078)	(0.074)	(0.232)	(0.212)	(0.216)
Importer rule of law	0.107 **)	-0.016	0.097 *)	-0.001	0.060	0.020
	(0.049)	(0.020)	(0.051)	(0.156)	(0.152)	(0.151)
Constant	-49.216 ***)	-40.560 ***)	-33.540 ***)	-105.730 ***)	-79.554 ***)	-77.307 ***)
	(5.386)	(4.138)	(4.157)	(16.629)	(15.317)	(18.446)
Observations	1682	1682	1682	1682	1682	1682
R^2	0.99	0.98	0.98	0.97	0.86	0.62
Time effects: $F(11, 1386)$	1.73 *)	1.41	1.47	5.77 ***)	6.67 ***)	6.45 ***)
Bilateral effects: $F(275, 1386)$	110.62 ***)	-	-	87.08 ***)	-	-
Hausman test: $\chi^2(20)$	163.60 ***)	-	-	118.83 ***)	-	-
Overidentification: $\chi^2(?)$	-	2.57	-	-	1.96	-
Canonical correlations	-	0.61	0.62	-	0.67	0.78

1) Standard errors in parantheses. ***) significant at 1%; **) significant at 5%; *) significant at 10%;