Trade, FDI and Cross-Variable Linkages: A German (Macro-)Regional Perspective

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Abstract

We analyse the evolution of German Trade and FDI activity within the EU27 using a simultaneous equation gravity approach for imports, exports, in- and outward FDI stocks based on German regional data (NUTS1-level) for 1993-2005. Our approach seeks to explore the main long-run driving forces of both trade/FDI and identify the likely linkages among them. Our motivation for a joint system estimation rests on the observation of a significant cross-equation residual correlation for single equation trade/FDI gravity models, which in turn opens up the possibility for enhancing estimation efficiency in a full information approach. 'On the fly' the simultaneous equation model also allows us to derive a measure for trade/FDI linkages based on the variance-covariance matrix of the system's error term. Adopting both a Hausman-Taylor (1981) IV approach (3SLS-GMM) and a rival non-IV estimator (the system extension to the Fixed Effects Vector Decomposition model recently proposed by Plümper & Tröger, 2007) our main results are: We find empirical support for the chosen gravity setup as an appropriate framework in explaining German trade and FDI patterns with a prominent role given to trade costs (proxied by geographical distance). Looking at cross-variable linkages we find a substitutive link between trade (both ex-/imports) and outward FDI for the average of German states in line with earlier evidence for Germany, while imports and inward FDI are found complement each other. We also analyse the sensitivity of the results for regionally disaggregated sub-aggregates among the total pool of German state - EU27 country pairs. The results hint at structural differences among the trade and FDI activity of the two German Eastern and Western macro regions on the one hand, and also their interaction with the 'core' EU15 member states opposed to the overall EU27 aggregate on the other hand. Taking the West German - EU27 trade & FDI relationship as an example, the identified pairwise linkages between the four variables closely follow the predictions of the New Trade theory model of Baldwin & Ottaviano (2001): That is, when trade is merely of intra industry type with non-zero trade costs, the latter shift production abroad and lead to export replacement effects of FDI. However, at the same time outward FDI may stimulates trade via reverse good imports. For the West German - EU15 aggregate we even reveal complementaries among export and FDI activity, which have not been identified for German data before. This strongly advocates the importance of the regional dimension in analysing cross-variable linkages among trade and FDI.

JEL-Classification: C33, F14, F21; Keywords: Trade, FDI, Panel Data, Simultaneous equations

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1 Introduction

In the last decades international trade and foreign direct investment (FDI) have been among the fastest growing economic activities in the world economy and thus played a key role in promoting the creation and subsequent development of international business relations. From the perspective of a nation's (or region's) overall economic development path, the evolution of trade and FDI is of particular interest given the empirically identified positive relationship between income growth and the degree of business internationalisation. The latter mainly stems from the existence of technological diffusion and spillover effects of internationalisation activity as well as the exploitation of market size effects of going abroad. These positive output effects in turn shift regional and national trade and FDI activities into the focus of public policy (e.g. for the design of appropriate trade/FDI promotion schemes) and thus calls for a profound analysis of trade-FDI patterns, their determinants and interplay.

Firms typically engage in cross-border trade in order to exploit international comparative advantages in the production process of goods and services (due to differences in the underlying technology or in factor endowments, competitive conditions, institutional framework etc.), serve larger markets than the home market or account for different tastes of customer preferences in providing goods and services in different regions. A firm's decision to engage in cross-border investment (FDI) is supposed to follow similar motives: First, firms may become multinationals in order to reduce their overall production costs (exploiting regional differences in labour costs, tax regimes and transportation costs among other factors). This cost-orientated FDI type is often referred to as *vertical* or *source seeking*. The second motive concerns the firm's aim to be close to customers and to locate in places where there are plenty of them (see e.g. Markusen et al., 1995, Tondl, 2001). The latter market-orientated FDI engagement is typically known as *horizontal* or *market seeking*.

Whereas the two types of FDI motives traditionally have been treated as substitutes, Helpman (2006) surveys new developments in the field of trade theory and international finance, which identify increasing complementaries among vertical and horizontal FDI: For example, large multinationals invest in low-cost countries (vertical motive), but with the particular focus to create export platforms from which they serve other national markets around (thus combining vertical with horizontal motives in a long-run perspective). Another question arising in this context is whether trade and FDI itself may be regarded as substitutes or complements: Does the creation of investment plants abroad (following horizontal investment motives) lead to reduced trade volumes since foreign markets are then served via the local production? Or does (vertical) FDI even increase international trade, e.g. via final (backwards) goods exports to the home market; and/or via enhanced cost competitiveness of multinational companies, which benefit from a unit cost reduction in foreign produced (intermediate) goods with respect to final good exportation? As the above examples show, with the emergence of rather complex investment strategies of multinational enterprises including a mixture of vertical and horizontal motives also the trade-FDI nexus becomes more puzzling.

From a theoretical point of view both types of trade-FDI linkages could hold. Thus, the absence of clear-cut theoretical results strongly calls for an empirical analysis to identify the main determinants of FDI and its interrelation with trade activity. In this paper we try to shed some more light on the above raised questions. We therefore analyse the intra-EU27 trade and FDI pattern for the 16 German federal states (NUTS1-level) based on a panel data set of bilateral state-to-nation trade volumes and FDI stocks covering a sample period from 1993 to 2005.[1] We apply gravity kind models in order to identify the driving forces of trade and FDI activity as proposed by the (New) trade theory and to gain insight into the likely nature of their interrelation. From an econometric point of view we estimate simultaneous equation gravity models accounting for a likely residual correlation among the individual trade and FDI equations. 'On the fly' this allows us to identify the underlying nature of the trade-FDI-nexus for Germany and its East/West macro regions.

The motivation for our analysis stems in particular from the following extensions to earlier studies in the field: First, our focus is set on regional rather than national data for Germany in order to identify more precisely whether close geographical and historical ties may promote trade in goods or international capital movements and whether these ties hold for or vary among German regions and their EU27 interaction partners. Beside the advantage of having more degrees of freedom for the empirical estimation with disaggregated data, the regional level can be seen as more closely linked to the level at which trade/investment flows actually take place - namely the firm level.[2] This may help to more accurately measure important explanatory variables such as geographical distance among trading/investment partners. From a regional modelling perspective we further aim to check for the sensitivity of the results with respect to the two West/East macro regions relative to the German aggregate results. This may give helpful insights into the (changing) role of international activities and their interplay in the process of economic

[1] Obviously, it would be desirable to have region-to-region trade/FDI data for Germany and the EU27 economies. Unfortunately no such records are available.

[2] The advantage of our data compared to micro (firm level) data is that we rely on trade/capital stock data which is freely accessible from public statistics (German Statistical office and German Central bank) and thus easily reproducible. The data is also free from any aggregation or related compilation error.

transformation and cohesion of the East German states.

Second, we apply both IV and non-IV estimators in a system approach. We especially focus on appropriate estimation techniques in simultaneous equation settings, when there is a prominent role for quantifying effects of time invariant explanatory variables, which are possibly endogenous with respect to the composed error term of the model. In the majority of studies using the gravity approach of trade and FDI a Fixed Effects Model (FEM) specification is chosen as preferred model in order to avoid potentially biased estimations from right hands side variable correlation with the unobserved individual effects. However, the disadvantage of the FEM is that it wipes out all time invariant explanatory variables, which we are particularly interested in here (e.g. with respect to distance). We thus use augmented model specifications, which enable us to include time invariant regressors and still account for potential biases stemming from unobserved individual effects and their correlation with time-varying and time invariant regressors: While the Hausman-Taylor model as our first option has previously been adopted to system estimation (see e.g. Egger & Pfaffermayr, 2004), for its non-IV rival in form of a two-step estimator in line with the Fixed Effects Vector Decomposition (FEVD) model recently proposed by Plümper & Tröger (2007) up to the knowledge of the authors a system extension has not been applied so far. Here we rely on bootstrapped standard errors in the second modelling step to adjust the degree of freedom in the presence of a 'generated regressand' (see also Atkinson & Cornwell, 2006).

Third, we aim to augment the empirical evidence on the nature of the trade-FDI nexus - as being complementary or substitutive in nature. The nature of the trade-FDI nexus is an issue that has for long concerned policy makers and thus shedding light on this puzzle might yield insightful information for the future formulation of trade policies. For example, the prevailing view that outward FDI and exports were predominantly substitutive in nature gave rise to the widespread adoption of import substitution policies during the 1960s and 1970s (see OECD, 2002). Pantulu & Poon (2003) point out that in industrialized countries trade substitutability and replacement effects are often a 'hot topic' in the globalization debate, where it is critically argued that outward FDI typically lead to deindustrialisation and displacement effects of employment – especially in export-based industries. Thus, for Germany as strong export driven economy this analysis is a very sensitive but nevertheless important issue. Only few empirical studies have dealt with German trade-FDI interrelations so far. Generally, either link between trade and FDI could hold from a theoretical perspective, crucially depending on the chosen model assumptions. The international empirical evidence so far tends to support the view of a rather complementary relationship, though results are highly country specific. For the case of Germany there is first evidence for a substitutive relationship between exports and outward FDI at the national level (see Jungmittag, 1995, for selected European countries and the USA as well as Egger & Pfaffermayr, 2004, for a world sample). Methodologically we follow the empirical path of the latter authors and additionally enrich the analysis by incorporating also import volumes and inward FDI stocks.

The remainder of the paper is organised as follows: Section 2 gives a short literature review with respect to recent theoretical and empirical contributions to analyse trade-FDI linkages in an international context. In section 3 we sketch the theoretical foundation of the gravity approach and derive its empirical form. Section 4 presents the database and some stylised facts for German trade and FDI within the EU27. Section 5 discusses the econometric specification and empirical results of the simultaneous equation modelling approach for the system of gravity models of trade and FDI as well as identifies the underlying trade-FDI nexus for Germany. We also perform a sensitivity analysis by splitting the panel of all German regions into the two West/East macro regions as well as distinguish between trade-FDI relations of German states with the full EU27 sample and the 'old' EU15 member countries. Section 6 finally concludes.

2 Literature review: Theory and Empirics

This section serves to give a short overview of recent theoretical and empirical contributions in determining trade-FDI linkages. From the perspective of the theoretical literature both type of interaction channels - favouring a complementary or substitutive relations among the variables - can be found.[3] To start with, the Heckscher-Ohlin (H-O) model with perfectly competitive product markets and no transportation costs as the standard workhorse model of traditional trade theory explains trade between two countries mainly on differences in factor endowments. In the absence of factor mobility (FDI) international trade serves as to equalize factor prices across countries. However, if factor mobility increases, difference in endowments diminish and trade volumes tend to decrease. Surveying recent theoretical contributions, Markusen (1995) shows that the substitutive H-O model predictions can also be extended to the case of imperfect competition.

A prominent approach of the latter type of modelling is the so-called proximity-concentration trade-off explored by Brainard (1993, 1997). According to this model the extent to which firms decide to engage in trade rather than foreign sales (FDI) depends crucially on the relative benefits of being close to the targeted market (assuming non-zero

[3]For exhaustive surveys see also Markusen (1995), Jungmittag (1995), Zarotiadis & Mylonidis (2005) and Blanchard et al. (2008).

trade costs) versus concentrating production in one location, which is associated with the exploitation of economies of scale. Thus, here trade and FDI are also merely seen as substitutes. Related firm-level approaches establish a similar kind of dichotomy based on the firm's choice of serving foreign markets in the light of cost differences between FDI (higher sunk costs) and exporting activity (higher unit costs).[4] A standard result established in micro-based models is that the firm's decision to become multinational is reflected in productivity differences, where the most productive firms engage in FDI, while less productive firms tend to export their goods or only serve home markets (the latter strategy being chosen by the least productive firms).[5]

On the contrary, there is also a bulk of recent contributions deriving complementaries between trade and FDI (mainly based on new trade theory with imperfect competition). The General Equilibrium model of Helpman (1984) models multinational enterprises (MNEs) as vertically integrated firms in a monopolistic competition environment with their choice of location for (intermediate) production being driven by relative factor costs and resource endowments. In this set-up FDI is more likely to create (inter-industry) trade rather than replace it. Consequently, from a vertical integrated modelling perspective trade and FDI are complementary with respect to differences in factor endowments. An alternative reason for positive linkages between trade and FDI may be found in the MNEs' intellectual property advantages, which may result in both increasing trade and investment activities where MNEs operate (see e.g. Brainard, 1997).[6]

Finally, Baldwin and Ottaviano (2001) starting from a critical reflection of the 'proximity-concentration trade-off' literature, show that complementary and substitutive elements in the trade-FDI activity may coexist:[7] In their model multi-product (differentiated) final good producing firms simultaneously engage in intraindustry trade and FDI based on the main idea that obstacles to trade generate a natural incentive for multi-product firms to do so. In the model non-zero trade costs shift production location to foreign affiliates so that in result FDI displaces some exports (as standard trade theory result), however it may also enhance trade via reverse imports of final goods since products in the model are differentiated. One of the advantages of the model is that the parallelism between the pattern of trade and investment is at the core of the model's driving mechanism. For our

[4]See e.g. Helpman et al. (2003).

[5]Similar results are also established by micro-related theories such as the descriptive OLI-Theorem (see e.g. Dunning, 1988). These models analyse exports and FDI typically as alternative modes of MNEs' internationalisation strategies.

[6]In similar veins is also the discussion of demand orientated complementaries given by Lipsey & Weiss (1984). Here it is assumed that a firm's production presence for one good in a foreign market may increase total demand for all of its products.

[7]Their main critique is that proximity-concentration trade-off models basically predict international commerce being dominated by either intraindustry trade or FDI without giving any role to (empirically) relevant two-way trade and FDI patterns between similar nations (in the same industry) - even if intermediate goods are taken into account.

empirical analysis of German trade/FDI activity within the EU27 the model may thus be seen as especially relevant, since it is explicitly designed to explain the behaviour of European MNEs and track back the specific European Trade-FDI pattern/nexus, with Europe being modelled as a rather closed trading area.

Extending on the (rather) amgiguous results of the theoretical literature there are also various empirical approaches aiming to pin down the trade-FDI-nexus. Though there is a general tendency for supporting complementary linkages when giving the floor to the data, the empirical literature also gives merely heterogeneous answers to this question: As Aizenman & Noy (2006) point out, important aspects to account for in the empirical set-up is to closely interpret the estimation result in light of the chosen country, industry sample and time period under observation. That is for example, with respect to positive trade-FDI linkages much more empirical support is found in the context of developing rather than developed countries (see e.g. Tadesse & Ryan, 2004). Another sensitive aspect in the modelling set-up is the sample period: As Pain & Wakelin (1998) point out, the nature of the trade-FDI linkage may change over time e.g. depending on the maturity of the investments and the accumulation of investments over time (that is the country's stage of internationalization). Long-established foreign affiliates increasingly come to have a relatively high local content in their output, while in the initial period capital goods imported from the investing country may be high. The latter may result in a temporary boost in positive export and FDI linkages. Indeed, Pain & Wakelin (1998) find for a sample of developing (OECD) countries that the positive correlation between exports and outward FDI turned from a complementary link throughout 1971-1985 to a substitutive one for the period 1986-1992.

From a methodological (and data) point of view the empirical approaches in search for trade-FDI linkages may be broadly classified into macro and micro (firm-level) studies. The latter are typically characterized by a detailed sectoral disaggregation. In the bulk of studies based on aggregate macroeconomic data predominantly gravity kind models have been applied: While the gravity model has a long tradition in estimating trade flows (see e.g. Matyas, 1997, Feenstra, 2004), gravity approaches explaining FDI flow/stock movements have a somewhat smaller literature base. However, as Brenton et al. (1999) point out, since the evolution of of FDI over the past three decades shares some common features with the evolution of trade (that is for instance having become more intensive between countries with similar relative high income levels, and having grown faster than income), the gravity model may also be useful in modelling the pattern of FDI. When using the gravity model as a vehicle for determining trade-FDI linkages, the analysis has to carefully select explanatory regressors as controls for a possible simultaneity bias between the endogenous trade and FDI variables of interest.

A simultaneity bias may arise because of a spurious correlation between trade and FDI when there are common exogenous factors that may both affect these variables. A common way to account for exogenous factor is to properly specify the trade and FDI equations and then use the estimation residuals to run a regression as $\lambda_{ijt} = f(\phi_{ijt})$, where λ_{ijt} is the residual of the FDI regression (with ij denoting bilateral interaction between country i and j, t is the time index) and ϕ_{ijt} is the residual of the trade regression (or vice versa).[8] Among the earlier contributions to this two-step approach determining trade-FDI linkages are Graham (1999) and Graham & Liu (1998), as well Brenton et al. (1999).

In the empirical literature the majority of papers focuses on the link between exports and outward FDI linkages, though recent findings indicate that the full set of cross-variable linkages may be of importance in identifying different types of cross-variable linkages:[9] For US data Lipsey & Weiss (1981, 1984) find a positive coefficient in regressing US outward FDI stocks on exports. Subsequently Brainard (1997), Graham (1999), Clausing (2000), Egger & Pfaffermayr (2004) as well as Fontagne & Pajot (1997) support this complementary view. For the UK Zarotiadis & Mylonidis (2005) find positive ties between trade and FDI based on inward FDI stocks as well as both export and import data. In the case of Japan the picture is rather different with the majority of studies revealing substitutive linkages: A negative export-outward FDI nexus is e.g. reported in Ma et al. (2000) and Bayoumi & Lipworth (1999). Only Nakamura & Oyama (1998) find trade expansion effects of outward FDI. For other country pairs (indcluding a macro-sectoral disaggregation) studies such as Bloningen (2001) for USA-Japanese trade and FDI relations as well as Goldberg & Klein (1999) for the USA and South American countries reveal mixed evidence with both complementary and substitutive elements depending on the chosen country and sector under considerations. Among the few studies using German data, Jungmittag (1995) and Egger & Pfaffermayr (2004) identify substitutive relationships - however only focusing on exports and outward FDI stock. A more detailed description of different empirical studies grouped by country focus is given in the appendix (table A.1).

[8] According to Pantulu & Poon (2003) as similar set-up would be to run an IV regression of trade on FDI with exogenous factors as instruments. This set-up then takes the form of a Pyndick-Rubinfeld test for simultaneity. Analogously, Pantulu & Poon (2003) recommend to use the variables from the gravity model as instruments for estimation.

[9] Detailed information with respect to country, variable and time period definition for selected studies - which have been reviewed in the prosecution of this work - are listed in the appendix (see table A.1). Moreover, type of data, chosen estimation technique and resulting trade-FDI linkages are briefly summarized.

3 Theoretical Foundation: The gravity model of trade and FDI

As the literature review shows, in studies adopting a macro perspective the predominant empirical modelling tool is the gravity approach. In this section we discuss the theoretical framework of gravity models and their ability to capture the main driving forces of trade and FDI activity for German regional data. The gravity model is a widely applied tool in the estimation of international trade and FDI activities and highly influential in terms of advising trade policy. The empirical success of the model may be best explained by two facts: It is easy to apply empirically and its results are remarkably good. Starting from the pioneering work of Tinbergen (1962) and Pöyhönen (1963) the model has received considerably attraction among economists and has recently undergone various developments yielding theoretical and econometric underpinnings (Matyas, 1997, Egger, 2000, Feenstra, 2004, or a special monograph on gravity models by Sen & Smith, 1995).

In its fairly simple specification the standard gravity approach explains trade between two countries as to be proportionate to the (economic) mass of the countries (typically measured by GDP and population) and inversely related to the distance between them adopting Newton's law for gravitational forces GF as

$$GF_{ij} = \frac{M_i M_j}{D_{ij}} \text{ for } i \neq j, \tag{1}$$

where $M_{i(j)}$ are the masses of two objects i and j, and D_{ij} the distance between them. While the first variables proxy supply and demand conditions at home and abroad, the latter serves to measure obstacles to trade. The basic model can be augmented by several other variables, Lamotte (2002) argues that the choice of variables constitutes an important and delicate point, which has to be guided by theoretical and statistical concerns.

Looking at its theoretical foundations, the gravity model can arise from a potentially large class of underlying economic structures. Anderson (1979), Helpman (1987) and Bergstrand (1985, 1989) were among the first to show that the gravity model can indeed be derived from a theoretical model. In the trade literature gravity type models based on classical Ricardian models, Heckscher-Ohlin models (see Deardorff, 1998) and increasing returns to scale models of the New Trade Theory have been presented since then. As Henderson & Millimet (2008) summarize, though being different in structure the models typically have the following common elements: i.) trade separability, which arises when local production and consumption decisions are separable from bilateral trade decisions among locations, ii.) the aggregator of differentiated products is identical across locations and is of the constant elasticity of substitution form, iii.) trade costs are invariant to trade volumes. Based on these assumptions and considering a one-sector economy, where consumers have a common elasticity of substitution σ among all goods as well as symmetric transportation costs among trading partners, Anderson & van Wincoop (2003) derive a theory consistent gravity model equation as

$$Y_{ij} = \frac{X_i X_j}{X_w}\left(\frac{T_{ij}}{P_i P_j}\right)^{1-\sigma} \text{ or: } Y_{ij} = kX_i X_j T_{ij}^{1-\sigma} P_i^{\sigma-1} P_j^{\sigma-1}, \quad (2)$$

where $k = 1/X_w$. Y_{ij} is the nominal value of exports from country i to j, $X_{i(j)}$ denotes total income for i (j), X_w is world income,[10] $(T_{ij}-1)$ reflect 'iceberg' transportation (trade) costs and $P_{i(j)}$ are further (multilateral) resistance variables as described Anderson & van Wincoop (2003). Iceberg transportation costs indicate that T_{ij} units of the product must be shipped to country j in order for one unit to arrive. Feenstra (2004) proposes to model trade costs T_{ij} as a function of distance d_{ij} and other 'border' effects associated with selling from country i to j.

The gravity model from eq.(2) is typically estimated in a log-linear form (for a detailed discussion of this point see e.g. Henderson & Millimett, 2008). Also one has to decide whether to estimate a cross-section or pooled regression setup. Whereas earlier empirical contributions have broadly been specified based on cross-sectional data, Egger (2000b) points out several advantages of the panel data approach over cross-section analysis: First, it catches unobserved heterogeneity in the data caused by time-invariant individual effects (cross-section specific). Second, it allows capturing the relationships between the relevant variables over a longer period and hence is able to identify the role of the overall business cycle phenomenon. Moreover, given the unobserved nature of P_i and P_j in eq.(2) a Panel data model proxying these effects (for region i and j and/or an interaction term of the form $i \times j$) may thus be a promising alternative to an modelling strategy that tries to directly calculate these resistance variables (see Feenstra, 2004, for an overview of different modelling strategies).

Given these clear empirical advantages over the cross-section approach in the following we use a panel data setup much in line with Cheng & Wall (2002), Serlenga & Shin (2006) or Egger & Pfaffermayr (2004). A general empirical approximation of the gravity model (with lower case letters denoting log-linear transformations) takes the following triple indexed form

$$y_{ijt} = \alpha + \beta' X_{ijt} + \gamma' Z_{ij} + u_{ijt} \text{ with } u_{ijt} = \mu_{ij} + \nu_{ijt} \quad (3)$$

[10]In a multi-country framework X_w is defined as $X_w = \sum_{i=1}^{C} X_i$ with $i, j = 1, \ldots, C$ countries.

Again, y_{ijt} represents country i's exports to country j for time period t and imports to i from j respectively (the same logic applies to imports as well as in- and outward FDI stocks[11]), with $i = 1, 2, \ldots, N$; $j = 1, 2, \ldots, M$ and $t = 1, 2, \ldots, T$. With regard to the explanatory variables on the right hand side of the equation X_{ijt} is a vector of explanatory variables with variations in three dimensions (home country, host country and time $[x_{ijt}]$), with variation only in time and home country $[x_{it}]$ or time and foreign country $[x_{jt}]$ respectively. Variables of this category are GDP, population, factor endowments, exchange rates etc. Z_{ij} is a vector of explanatory variables which do not vary over time but across i and j (such as distance, common border etc.). β and γ are vectors of regression coefficients, α is the overall constant term and u_{ijt} is the composed error term including the unobservable individual effects μ_{ij} (country pair or individual country/region effects) and a remainder error term ν_{ijt}. Typically the latter two are assumed to be i.i.d. residuals with zero mean and constant variance.

In the gravity model literature different explanatory variables have been proposed to properly account for the above sketched underlying theoretical concepts. In our case the set of time varying explanatory variables (X_{ijt}) for the trade equations (both im- & export flows) includes: GDP for home region and foreign country, population at home and abroad, as well as variables, measuring the relative share of inter-industry trade (or vertical vs. horizontal FDI respectively) based on an index of the similarity of economic size (SIM) and relative factor endowments (RLF).[12] The variable SIM captures the relative size of two countries in terms of GDP assuming that we can model each German state as an individual small open economy (SOE). The variable takes values between zero (absolute divergence) and 0,5 (equal country size). RLF captures differences in terms of relative factor endowments, where we assume that these endowments are closely linked to per-capita GDP as a proxy for the former. The RLF variable takes a minimum of zero for equal factor endowments in the two regions. Based on recent findings in New Trade Theory models we also test the effect of home and host country labour productivity (defined as GDP per total employment) on trade. We finally specify a (one) time-varying dummy to check for trade/FDI-creating effects of the EMU starting from 1999.

The economic interpretation of the vector of time-varying variables $[X_{ijt}]$ is as follows: For the export equation (and imports vice versa) GDP levels at home and abroad are expected to be positively correlated with the level of exports (imports) reflecting the

[11]Thus, throughout the analysis i always stands for the German states, while j represents the EU27 trading partner countries.

[12]In specifying the latter variables we follow Egger (2001) and Serlenga & Shin (2006). See the variable description in the appendix for further details.

theoretical argument that the supply and demand for differentiated varieties increases with absolute higher incom values. A similar connection can also be established if we substitute absolute income levels by per capita GDP in i and j as a proxy for welfare levels. Contrary, the effect of population is not that clear cut: The most prominent interpretation is offered by Baldwin (1994) that both home and foreign country population levels are negatively related to trade, since larger countries tend to be more self-sufficient in terms of production and resource endowment. An alternative interpretation is that a positive impact of exporter population on trade indicates labour intensive good exports, while a negative one stands for capital intensive export dominance (see e.g. Serlenga & Shin, 2006).

In this line of argumentation a positive correlation of foreign population and trade may indicate exports in necessity goods (a negative one luxury goods). Next to GDP or GDP per capita level we may also consider productivity measures at home an abroad: With respect to home (foreign) country productivity we expect a positive influence on exports (imports) inspired by recent New Trade theoretical findings that more productive firms on average tend to have a higher degree of internationalization. SIM may serve as an indicator for the relative share of intra-industry trade. That is, the more similar countries are in terms of GDP, the higher will be the share of intra-industry trade. The interpretation of RLF is in similar veins (but of opposite coefficient sign): For increasing differences in factor endowments, we expect a rise in the relative share of inter-industry trade. For the EMU dummy we expect that the creation of the monetary unit has induced positive trade/FDI effects for its member states.

We use roughly the same set of time-varying variables for the gravity models of FDI (both inward and outward), and - as Brenton et al. (1999) point out - the economic interpretation of the explanatory variables is much conform: As in the case of trade, FDI is expected to be positively related to the level of income at home and abroad as a proxy for a large domestic market, and negatively to population indicating that large population sized countries are expected to be more self-sufficient in terms of investment. An alternative interpretation would be that a positive correlation of FDI with a country's population indicates an FDI engagement of vertical type, since population is expected to the more abundant production factor with a lower price for labour.

For transition countries (such as East Germany and CEEC member states) one could also consider a different interpretation of the population coefficient: Here the population level may capture the market potential effect of FDI much better than GDP related variables, reflecting the underlying hypothesis that the latter variables are still below their long-run trends alongside the catching-up process. Hence, population levels as a proxy for the market potential effect are assumed to be postively correlated with FDI activity. As for trade we also include the variables SIM and RLF in the FDI equations as a potential indicator of the bilateral share of horizontal or vertical investment activities. Thereby, two similar countries (in terms of absolute GDP levels and/or factor endowments) are expected to engage more in horizontal than vertical FDI.

For the FDI models we additionally augment the vector of time-varying variables by further endowment based variables derived from the New Trade Theory (see e.g. Borrmann et al., 2005). We include labour force specific skill variables and factor prices in the host country such as aggregate wage levels as well as FDI agglomeration forces proxied by the degree of FDI openness of the host country (e.g. defined as total inward FDI stock relative to GDP or alternatively the total per capita capital stock of the host country). We expect that agglomeration forces are typically positively related to the FDI activity. The effect of the wage level in the host country is a priori not clear: If vertical FDI activities are the dominant driving force it should turn negative, for a dominance of horizontal FDI also a positive relationship between the wage level and FDI activity could be true (indicating the need for a qualified workforce in foreign affiliate production and sales).

The set of time invariant variables (both in the trade and FDI equations) includes geographic distance as proxy for transportation costs in the case of trade or fixed plant set-up and monitoring costs in the case of FDI. The role of distance has become one of the major research topics in trade theory, while typically a negative influence on both variables is assumed in the gravity model literature (see e.g. Markusen & Maskus, 1999).[13] We further specify a dummy variable for differences in the export/FDI behaviour of the East German states catching up historical and/or structural differences between the two German macro regions. Based on earlier research we test the hypothesis whether the East German firms are still below their trade and investment potential.[14] We also test for neighbouring (border) effects and measure the deviation of trade and FDI from German regions to the Central and Eastern European Countries (CEECs) compared to the 'core' of the EU15 member states.[15]

Generally, neighbouring effects are assumed to have a positive impact on trade and FDI

[13] However, Egger & Pfaffermayr (2004) argue that though distance can be regarded as an obstacle to both trade and FDI, the two variables still may be seen as complements (rather than substitutes) with respect to this proxy for trade costs depending on the relative importance of plant set-up costs versus pure trade costs. Trade theory suggests that firms will tend to engage in FDI at the costs of trade as transport costs (proxied by distance) rise. More distant markets will tend to be served by overseas investments in firm affiliates rather than by exporting. Their hypothesis thus gives rise to a further proposal on how the estimate gravity models of trade and FDI properly, namely in an adequate simultaneous equations specification that explicitly accounts for the common determinants.

[14] See Alecke et al. (2003).

[15] The CEEC aggregate includes Hungary, Poland, the Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Romania and Bulgaria.

due to historical, cultural and personal ties between the trading and investment partners. The expectations about the trade and FDI volume of German regions with the CEECs is not that clear a priori. For bilateral trade several studies have revealed that German trade with the CEECs has increased rapidly after the transformation of these countries towards market economies in the early 1990s and that trade volumes now are already above their potential (relative to a 'normal' trade level derived from the gravity model's determining factors) so that the dummy coefficient for trade is expected to be positive - in particular for exports from Germany to the CEECs.[16] With respect to the FDI stock it is questionable whether the short time span after the transformation to market economies is sufficient to build up a 'normal' FDI stock (in the sense of the gravity model estimates), we thus expect a negative sign for the dummy variable coefficient with respect to outward FDI. The same logic applies for inward FDI. The total set of candidate variables for inclusion in the estimation procedure together with their theoretically motivated signs are summarized in table 1.

<< insert Table 1 about here >>

4 German Trade-FDI within the EU27: Data and stylized facts

For empirical estimation we use a panel data set for 16 German states (Bundesländer) and the EU27 member countries to estimate log-linear gravity models, which gives a total of 368 country pairs (16 states x 23 country relationships).[17] Our database covers a time period of 13 years (1993 - 2005). Due to missing data and data privacy reasons we have to cope with an unbalanced panel. Matching the data for the export, import, outward and inward FDI model we get non-missing data for 353 out of the 368 pairs. A general measure for the unbalancedness of panel data is given by Ahrens & Pincus (1981) defined as $\varpi = NM/[\bar{T}\sum_{i=1,j=1}^{NM}(1/T_{ij})]$, where $\bar{T} = (\sum_{i=1,j=1}^{NM} T_{ij}/NM)$ and $0 < \varpi \leq 1$ with NM as total number country pairs and T_{ij} as time observations per country pair. Thus, ϖ takes the value of one when the pattern is balanced and gets smaller with increasing unbalancedness of the data. In the case of our data set the value of $\varpi = 0,70$ indicating that the degree of imbalancedness in our data is rather low.[18]

[16] See e.g. Collins & Rodrik (1991), Wang & Winters (1992), Hamilton & Winters (1992), Baldwin (1994), Schumacher & Trübswetter (2000), Buch & Piazolo (2000), Jakab et al. (2001), Caetano et al. (2002) as well as Caetano & Galego (2003).

[17] Where we excluded Malta and Cyprus due to their specific characteristics as 'island' economies, further we treat Belgium and Luxembourg as one single economy mainly due to statistical data reasons.

[18] Im- and export data is balanced for the whole sample. In the FDI equation we distinguish between zero FDI stock and not reported values. The latter are handled as missing data while we substitute zero trade flows by a small constant in order

With the gravity model literature having its root in cross-sectional estimation in most cases little attention has been paid to the time series properties of the variables in focus even if empirical application predominantly has switched to panel data estimation recently (exceptions are e.g. Fidrmuc, 2008, Zwinkels & Beugelsdijk, 2008). While for the standard microeconometric panel data model with $N \to \infty$ and fixed T the assumption of stationarity may be seen as justified, it becomes less evident for macro panels with increasing time dimension. Since our data with $N = 353$ and max. $T = 13$ is at the borderline between classical micro and macro panel data, we aim to explicitly care for the time series properties of the variables employed in our empirical model in order to avoid the problem of spurious regression among non-stationary variables that are not cointegrated. Different tests have been proposed to test for unit roots in panel data, however only few are directly applicable to unbalanced data without inducing a bias to the test results (see e.g. Baltagi, 2008, as well as Breitung & Pesaran, 2008, for an overview). Here we rely on a Fisher-type testing approach which combines the p-values of unit root tests for each cross section i as proposed by Maddala & Wu (1999) and Choi (2001). The null hypothesis of the test is that the series under observation is non-stationary. Fidrmuc (2008) alternatively proposes the CADF test from Pesaran (2007), which also works with unbalanced panel data. We use the CADF test to double check those variables for which we do not reject the null of a unit root in the series based on the Fisher-type test. One has to not the the null in Pesaran's (2007) CADF test is that the series is stationary.

The results of the panel unit root tests for the variables in levels are given in table 2. The results show that the null hypothesis of a unit root can be rejected for the majority of variables (with $PROD_{jt}$, RLF_{ijt} and $WAGE_{jt}$ being found to be trend-stationary, while only for $FDIin_{ijt}$ and $FDIopen_{ijt}$ both test specifications - that is including a constant as well as constant and deterministic trend - do not reject the null of a unit root in the series). We therefore additionally compute the Pesaran's CADF test results for these variables, which in fact do not reject the null of stationarity. Nevertheless we are somewhat cautious in using the results of the unit root tests since Binder et al. (2005) clearly point out that only because we have a short time dimension in our sample (as basis for statistical testing) this does not mean that the underlying data could not have arisen from non-stationary processes. For our empirical estimation we take this argument into account and additionally perform a residual based unit root test for cointegration in the spirit of Kao (1999) on our final model specification to avoid the risk of running spurious regressions (see e.g. Baltagi, 2008, or an overview). Even for the case of non-stationary

to use log-linear gravity models (for an overview of different methods of dealing with zero trade flows in the gravity model context see e.g. Linders & de Groot, 2006).

variables we basically assume that standard estimators such as the FEM (e.g. as part of the FEVD approach) have good empirical properties for long-run gravity model estimation as recently found in Fidrmuc (2008). This may in particular also hold for models with mixed I(1)/I(0) variables, where the latter are typically due to time-fixed regressors. Estimation techniques for such data settings have recently been discussed in Zwinkels & Beugelsdijk (2008).

<< insert Table 2 about here >>

Before we turn to the specification of the empirical model used throughout this paper, we aim to highlight some stylised facts of the German trade and FDI pattern - both from an aggregate as well as a regional perspective. One of the main characteristics of the German economy is its relatively strong engagement in international trade: In 2005 German exports accounted for approx. 9,5 % of total worldwide merchandise flows - rendering Germany the world's leading exporting nation ahead of the USA (8,9 %), China (7,5 %) and Japan (5,9 %). Correcting for differences in economic size the openness ratio (OR) defined as total volume of imports and exports relative to a country's GDP shows an even stronger difference between Germany and the other top exporting nations: With 53,4 % for Germany in 2005, the respective OR for the US (17,9 %) and Japan (20,6 %) was considerably lower.[19]. This picture is also true in an intra-European comparison (e.g. looking at the OR for Italy = 37,2 %, UK = 34,8 % and France = 40,8 %) Taking a closer look at the bilateral trade pattern of Germany with its major trading partners, for import data among the 10 major partners 6 are from the EU27 and for exports these are even 8 out of 10 in 2005, indicating that intra-EU trade amounts for a considerable part of Germany's total trade. The share of German EU27-trade relative to worldwide trade is 67,2 % (average for the period 1993-2005). The share of German imports from the EU27 relative to total imports is almost equally high (64,8 % as average for the period 1993-2005).

The strong activity of German firms on international markets can also be observed with respect to FDI data: In the year 2005 the total outward FDI stock hold by German firms was only outranked by its US and UK competitors. Again correcting for economic size, we see that Germany with an FDI ratio of 34,6 % of national GDP outranks the US (16,4 %) though the gap to the UK (56,25 %) remains. Compared to the export share, the EU27-wide outward FDI share (relative to the total outward FDI stock) is somewhat lower

[19] Only the OR of China was with 69,7 % in 2004 even larger

(average for 1993-2005: 51,9 %), but still amounts a significant part.[20] The percentage share of the inward FDI stock from EU countries for this period is extremly high in the case of Germany (73,8 % relative to total inward FDI).

Taking a regional disaggregated perspective, table 3 and table 4 show the average trade and FDI shares (defined as regional percentage share of the national aggregate) for the 16 German federal states (Bundesländer) and the two average periods 1993-1999 and 2000-2005. Table 3 shows that the regional export shares remain broadly stable for the two periods analysed. The population intense German states North Rhine-Westfalia, Bavaria and Baden-Württemberg account for almost two-third of total and intra-EU exports. Taking a closer look at the West and East German macro regions, the table shows that the West German states take by far the lion's share relative to the East German export activity: For the period 1993-1999 around 94 % of total exports and also intra-EU exports come from the West German state, only roughly 6 % from the East.[21] These findings give a first indication that the East German firms are still lacking behind in their export activity compared to the West German counterparts (for comparion: the population share of the East German macro region relative to the German aggregate is around 17 % for this time period). For the period 2000 to 2005 the share of East German exports gradually raises to 7-8 %, giving a first (weak) sign for a gradual catching up. For imports we see broadly the same regional pattern as in the export case.

With respect to regional (in- and outward) FDI shares the picture is more heterogeneous, especially for the two macro regions West and East: While for outward FDI stocks the gap between West and East is far bigger than in the trade case (only 1-2 % of total outward FDI come from East German stats), for inward FDI the share is more in line with the relative trade weights. Moreover, while there was a considerably high share of inward FDI from the EU27 countries to East Germany for the average 1993-1999 (around 6,3 %), this positive trend seems to be only of a temporary manner: For the average of the years 2000-2005 the inward FDI share to East Germany shrinks back to 3,4 %, in line with the regional distribution of worldwide inward FDI stocks. A graphical plot of the regional distribution of trade and FDI shares is given in figure 1.

<< insert Table 3 and 4 about here >>

<< insert Figure 1 about here >>

[20] The remainder part of Germany's outward FDI stock is mainly directed to the US (29,6 % in 2005).
[21] Both macro regions excluding Berlin.

Looking at regional trade and FDI intensities (defined as regional trade volume / FDI stocks per regional GDP), table 5 and table 6 report the regional intensities relative to the German average (where the latter is normalised to one): Federal states with the highest total export intensity are Bremen (1,83 for 2000-2005), Saarland (1,47) and Baden-Württemberg (1,36). The figures are roughly similar for total as well as intra-EU exports. One major exception is the Saarland which has a significantly higher intra-EU trade intensity (1,91) compared to the total trade intensity (1,47). Since the Saarland has a common border with France (and strong cultural ties), this may be seen as a first indication for a positive trade effect of a common border and close distance ties to EU trading partners. Examining the differences between the two macro regions West and East Germany, table 5 shows that the East German states - accounting for differences in economic size - trade half as much as the German average (0,52 both for total as well as intra-EU trade for the average 2000-2005). The West-East gap is slightly wider for import intensities. Both ratios reflect the general tendency that the East German states are still much less involved in international trade compared to the West German counterparts. The most import intensive regions - apart from the city states Bremen and Hamburg - are Hessen (1,12 for total imports between 2000-2005), North Rhine-Westphalia (1,12) and the Saarland (1,45). For the later the import intensity of EU27 countries is again much higher (1,97).

With respect to the FDI intensities table 6 shows that the southern states Hessen (2,32 for the period 2000 to 2005), Baden-Württemberg (1,33) and Bavaria (1,15) have the highest outward FDI activity after adjusting for absolute GDP levels. Especially for Hessen the FDI activity is two-times higher than the German average. The distribution of outward FDI to the EU27 member states is somewhat different: Although Hessen (1,65 for 2000 to 2005) is still the region with the highest intensity of capital exporting multinationals, its relative dominance compared to the German average is a lot smaller. On the contrary Bavaria (1,44) and Rhineland-Palatine (1,32) focus much more on intra-EU FDI activity, while Baden-Württemberg - with a total outward FDI intensity of 1,32 - is considerably below the German average for EU wide FDI activity (0,89).

For the five East German states (Brandenburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt and Thuringia) the outward FDI activity is extremely low (0,06 for total and 0,04 for intra-EU FDI stocks). This much stronger gap between West and East German states compared to trade intensities may be due to several reasons: One may be clearly attributed to path dependences in building up foreign capital stocks. Here, the East German states have a clear time disadvantage compared to the West German states since transformation to market based economies took only place starting from the early 1990s. However, while for the export activity a gradual catching-up of the Eastern relative to the Western states could be observed for outward FDI stocks the gap remains stable or even widens recently. We therefore may expect other persistent structural differences (e.g. significant productivity and competitiveness gaps between West and East German firms) as explanations for a much lower FDI activity. Again, for inward FDI the East-West gap is somewhat smaller, mirroring the broad picture that the Eastern states throughout their economic transition process are able to act as a host country for FDI, but with little options for actively export capital to other EU countries. The macro regional differences for trade and FDI intensities within the EU27 are shown graphically in figure 2.

Summing up, the regional perspective of German state export and FDI activity shows, that we detect strong regional difference for which we have to account when setting up a model that includes economic and geographic variables in explaining the export and FDI performance of German states.

<< insert Table 5 and 6 about here >>

<< insert Figure 2 about here >>

5 Econometric specification and estimation results

In this section we estimate gravity models for im-, export, outward and inward FDI activity in jointly in a simultaneous equation approach. We thereby carefully account for the trade-off between the likely increase of estimation efficiency based on a full information system approch, if we observe a significant correlation of the residuals from a single equation estimation of the respective gravity models, and the additional complexity brought into the estimation system by full information techniques, which in turn may translate into increasingly biased results if estimation errors from one equation are pumped through the whole system.

The use of simultaneous equations models with panel data is less common in econometric practice: However, Cornwell et al. (1992), Baltagi (1980, 1981 and 2008), Baltagi & Chang (2000), Prucha (1984), Krishnakumar (1988), Biorn & Krishnakumar (2008) as well as Park (2005) among others discuss both fixed effects and random effects panel data estimators in a system manner where right hand side endogeneity matters. Our goal here is to apply both IV and non-IV approaches to the simultaneous equation approach for the trade/FDI system. IV estimation thereby builds on the Hausman-Taylor (1981) model as the standard estimator in the field, while the non-IV alternative centers around a FEM based two-step estimator, which has shown a good performance both in Monte Carlo simulations and empirical applications to gravity model estimation recently.

Generally speaking, the most common way to estimate a system of equations is to make use of Zellner's (1962) seemingly unrelated regression (SUR) approach or 3SLS if IV regression is necessary. The SUR model thereby may be seen as a special case of the more general 3SLS estimator when there is no right hand side endogeneity in the estimated equations (for details see e.g. Intrilligator et al., 1996). The SUR approach is popular since it captures the correlation of the disturbances across equations, so that it is asymptotically more efficient than standard OLS if the residual correlation is significantly different from zero. However, for the case we have to cope with IV regression due right hand side endogeneity, Baltagi (2008) proposes to use 3SLS estimation. In comparison to the SUR estimation the 3SLS is estimated in subsequent steps and thus allows for the inclusion of instrumental variables and different from the standard 2SLS estimator it thereby explicitly incorporates cross-equation information of the system's error term variance-covariance matrix.[22].

For estimation purposes we may start writing the system's n^{th} structural equation according to eq.(3) as:

$$\begin{aligned} y_n = & \quad R_n\xi_n + u_n \\ u_n = & \quad \mu_n + \nu_n, \end{aligned} \tag{4}$$

where n denotes the n^{th} structural equation of the system with $n = 1, \ldots, M$ equations (in our case $M = 4$), $R_n = (X_n, Z_n)$ and $\xi = (\beta', \gamma')$. Following Cornwell et al. (1992) we then simply stack the equations into the usual 'starred' form as:

$$y_* = R_*\xi + u_*, \tag{5}$$

where $y'_* = (y'_1, \ldots, y'_N)$ and similar for ξ and u_*. R_* is defined as

$$R_* = \begin{bmatrix} R_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & R_M \end{bmatrix} \tag{6}$$

For system estimation of eq.(5) we first specify the Hausman-Taylor (1981) model as a hybrid version of the Fixed Effects (FEM) and Random Effects (REM) model. In a nutshell, the idea of the Hausman-Taylor estimator is to derive consistent instruments from internal data transformations to cope with the possibility of endogeneity in the model, but

[22]See e.g. Cornwell et al. (1992) as well as Baltagi & Chang (2000)

still avoid the strong 'all or nothing' assumption of the FEM and REM in terms of residual correlation of the right hand side regressors respectively (see e.g. Wooldridge, 2002, for details). The Hausman-Taylor model therefore splits both the vectors of time-varying and time-fixed variables into two subvectors classifying the variables as either correlated or uncorrelated with the unobservable individual effetcs. This classification scheme is then used to derive consistent IVs for model estimation (see appendix A for some further details on the estimation strategy, in particular for unbalanced panel data).

Since the Hausman-Taylor model centers around IV estimation, in a system context the 3SLS estimator is the natural choice (or in a broader context system GMM methods).[23] For specification purposes, next to consistent IV choice for estimation purposes one also has to decide about the proper empirical form of the system's error term variance-covariance matrix. In its standard form the model typically builds on the random effects assumption in line with Baltagi's (1981) feasible EC-3SLS estimators as probably the most prominent example in the field of system estimation with Panel data. As Cornwell et al. (1992) show, the EC-3SLS estimator can be interpreted as a special form of the more general HT-3SLS framework, namely when all exogenous variables are assumed to be independent of the system's error components. Alternatively, Ahn & Schmidt (1999) propose to start with an unrestricted covariance matrix in the context of optimal system GMM estimation and then test for valid model (variance-covariance) restrictions. For the purpose of this paper we specify the Hausman-Taylor model in its 3SLS-GMM form as:

$$\hat{\beta}_{3SLS-GMM} = [R'_* H_* (H'_* \hat{\Omega} H_*)^{-1} H'_* R_*]^{-1} R'_* H_* (H'_* \hat{\Omega} H_*)^{-1} H'_* y_*, \tag{7}$$

where H^S_* is the system's total IV set based on the definition $H^S_i = I_M \otimes H_i$ (with H_i as the n^{th} equation instrument set) and $u^S_i = (u'_{1i}, \ldots, u'_{M,i})$, so that we can write the system's overal set of moment conditions compactly as $E(H^{S\prime}_i u^S_i) = 0$. The latter in turn is chosen according to the Hausman-Taylor (1981) assumptions. $\hat{\Omega} = Cov(u_*)$ is the variance-covariance matrix of the system's error term. The main difference between the standard 3SLS estimator and its 3SLS-GMM alternative is that the latter allows for different instruments in subsequent equations, while standard 3SLS estimation assumes the same IV-set applies to every equation in the system. The latter assumption may be somewhat problematic in our case, since we have found that different instruments are valid for subsequent model equations based on a series of Hansen (1982)/Sargan (1958) overidentification tests for the single equation benchmark models (see table A.3 to A.6 in

[23] The system extension to the standard single equation Hausman-Taylor models was first proposed by Cornwell et al. (1992), a GMM version of the estimator is discussed in Ahn & Schmidt (1999).

the appendix).

For convenience and in line with the mainstream literature on the Hausman-Taylor model we assume that Ω_* takes the random effect form.[24] We thus model the two error components μ_{ij} and ν_{ijt} as i.i.d. with $(0, \Sigma_\mu)$ and $(0, \Sigma_\nu)$, where $\Sigma_\mu = [\sigma^2_{\mu_{(j,l)}}]$ is the 4x4 variance-covariance matrix corresponding to the unobserved individual effects (with $j, l =$ [exports, FDI out, imports, FDI in]) and $\Sigma_\nu = [\sigma^2_{\nu_{(j,l)}}]$ is the 4x4 variance-covariance matrix of the remainder error term. For unbalanced panel data the variance-covariance varies with ij and therefore transforming the estimation system by $\Omega_{ij}^{-1/2}$ takes the following form (for details of Hausman-Taylor estimation in unbalanced panels see appendix A):

$$\Omega_{ij}^{-1/2} = (\Sigma_\nu + T_{ij}\Sigma_\mu)^{-1/2} \otimes P + \Sigma_\nu^{-1/2} \otimes Q. \tag{8}$$

where Q is an operator transforming a variable into its deviations from group means, while P produces group means of a variable. P for each pair is defined as $J_{T_{ij}}/T_{ij}$, where $J_{T_{ij}}$ is an $(T_{ij} * T_{ij})$ matrix of ones. Q is defined as $I_{T_{ij}} - P$, where $I_{T_{ij}}$ is an identity matrix of dimension T_{ij}. In empirical terms we use the feasible GLS approximation in order to replace the unknown parameters of covariance matrix, Σ_ν and $(\Sigma_\nu + T_{ij}\Sigma_\mu)$ by consistent estimates. To derive these proxies we follow Baltagi's (2008) suggestion for unbalanced panels and estimate the respective subblocks (or matrix elements) of $\hat{\Sigma}_\nu$ and $\hat{\Sigma}_\mu$ as

$$\hat{\sigma}^2_{\nu_{(j,l)}} = \frac{\hat{u}'_{j,l} Q \hat{u}_{j,l}}{\sum_{i=1,j=1}^{NM}(T_{ij} - 1)}, \tag{9}$$

$$\hat{\sigma}^2_{\mu_{(j,l)}} = \frac{\hat{u}'_{j,l} P \hat{u}_{j,l} - NM\hat{\sigma}_{\nu_{(j,l)}}}{\sum_{i=1,j=1}^{NM}(T_{ij})}, \tag{10}$$

where $\hat{u}$ are the estimation residuals from an untransformed 1.step Hausman-Taylor typoe 2SLS estimation (see also Baltagi, 2008, or Baltagi & Chang, 2000, for details).[25]

As an alternative to the Hausman-Taylor IV estimator we further apply a non-IV two-step modelling approach, which basically builds on the Fixed Effects Model (FEM) but also allows to quantify the effects of time-fixed variables, which are wiped out by the within-type data transformation in the standard FEM. To avoid this problem the

[24]An alternative choice for Ω_* would be an unrestricted form in analogy to the optimal weighting matrix for system GMM as $\Omega = (I_N \otimes \Sigma_{j,l})$, where $\Sigma_{j,l}$ can be estimated from any consistent 1.step residuals according to $\Sigma_{j,l} = N^{-1}\sum_{i=1,j=1}^{NM}(\hat{u}_j \hat{u}'_l)$ (see Ahn & Schmidt, 1999, for details).

[25]In transforming the system we follow Baltagi (2008) and apply the Cholesky decomposition to Σ_ν^{-1} and Σ_μ^{-1}.

two-step approach estimates the coefficient vector of the time-varying variables by FEM in a first step and then applies pooled OLS (POLS) in a second step, where the latter involves a regression of the first step group mean residuals (as a proxy for the unobserved individual effects) against the vector of time-fixed variables to obtain the coefficient vector for these variables. Since this second step includes a 'generated regressand' we have to adjust standard errors here.

The idea for two-step estimation has recently been proposed by Plümper & Tröger (2007) and since then been applied in a variety of empirical contributions - especially focussing on gravity type models (see e.g. Belke & Spies, 2008, Caporale et al., 2008, Etzo, 2007, and Krogstrup & Wälti, 2008, among others). Details about the estimation strategy for Plümper & Tröger's Fixed Effects Vector Decomposition (FEVD) approach are given in appendix B.[26] Recent Monte Carlo simulation experiments confirm the overall good empirical performance of the non-IV approach, which is found to be superior relative to the HT estimator especially in terms of getting the time-fixed variable coefficients right (see e.g. Alfaro, 2006, Plümper & Tröger, 2007, Mitze, 2008). Moreover, one major advantage of the non-IV specification compared to the Hausman-Taylor approach is that no arbitrary ex-ante selection of consistent moment conditions (IVs) is necessary, and the approach avoids the risk of running into the weak instrumentation problem, which may well apply to the former approach and result in a substantial finite sample bias.

In the context of the FEVD-type two-step estimator combining FEM/POLS estimation in subsequent modelling steps the adaption to a system approach is rather straightforward: That is, for the FEM model Cornwell et al. (1992) show based on the conditional likelihood interpretation of the within-type transformation that in the absence of any assumption about the individual effects, we cannot do better than apply an efficient estimator (such as 3SLS/SUR) to the within-type transformed model. Analogously, for POLS - which ignores individual heterogeneity - the model can be directly applied in a SUR framework adjusting for the error term variance-covariance matrix of the system by GLS estimation. In analogy to the FEVD single equation approach by Plümper & Tröger (2007) we will label the newly proposed system extension throughout the remainder of our analysis as FEVD-SUR.

To adjust standard errors (SE) in the second regression step we choose bootstrapping techniques as discussed in Atkinson & Cornwell (2006), which is computationally simpler than using an asymptotic covariance matrix correction as e.g. proposed by Murphy & Topel (1985). Since we are interested in deriving heteroscedasticity-robust SEs we apply

[26]The widespread use of the FEVD model is supported by the provision of a Stata routine (*xtfevd*) written by the authors.

the 'wild bootstrap' procedure, which has shown a good empirical performance in variety of Monte Carlo simulation experiments (see e.g. Davidson & Flachaire, 2001, MacKinnon, 2002, and Atkinson & Cornwell, 2006). The 'wild bootstrap' approach is implemented through the following steps as outlined in Atkinson & Cornwell (2006):[27]

Step 1: Estimate the coefficient vector $\hat{\beta}_{FEM-SUR}$ of X_{it} in a SUR system based on the within-type transformed data (FEM)

Step 2: Using the coefficient vector $\hat{\beta}_{FEM-SUR}$, we compute

$$\hat{\pi}_i = \bar{y} - \hat{\beta}_{FEM-SUR}\bar{X}_i \tag{11}$$

Step 3: Estimate the coefficient vector $\hat{\gamma}_{POLS-SUR}$ for Z_i by POLS-SUR

Step 4: Compute the second step residuals as

$$\hat{\xi}_{it} = y_{it} - \hat{\beta}_{FEM-SUR}X_{it} - \hat{\gamma}_{POLS-SUR}(J_T \otimes Z_i) \tag{12}$$

According to the 'wild bootstrap' procedure replace $\hat{\xi}_{it}$ with

$$f(\hat{\xi}_{it})\tilde{v}_{it} \text{ where } f(\hat{\xi}_{it}) = \frac{\hat{\xi}_{it}}{(1-h_{it})^{1/2}} \tag{13}$$

and h is the model's projection matrix so that a division by $(1-h_{it})^{1/2}$ ensures that the the transformed residuals have the same variance (for details see MacKinnon, 2002); $\tilde{v}_{it}$ is defined as a two-point distribution (the so-called Rademacher distribution) with

$$\tilde{v}_{it} = \begin{cases} -1 \text{ with probability } 1/2 \\ -1 \text{ with probability } 1/2 \end{cases} \tag{14}$$

Step 5: For each of $i = 1, \ldots, N$ blocks, we draw randomly with replacement T observations with probability $1/T$ from $\tilde{v}_{it}$ to obtain $\tilde{v}^*_{it}$

Step 6: Generate

$$y^*_{it} = \hat{\beta}_{FEM-SUR}X_{it} - \hat{\gamma}_{POLS-SUR}(J_T \otimes Z_i) + \tilde{v}^*_{it} \tag{15}$$

Step 7: Compute the FEM-SUR for the vector of variable coefficients β using the starred data as $\beta^*_{FEM-SUR}$

[27] For notational convenience the cross-section dimension is expressed by i rather than ij here.

Step 8: Using $\beta^*_{FEM-SUR}$ from the previous step to compute

$$\omega_i = \bar{\tilde{\xi}}_i - (\hat{\beta}^*_{FEM-SUR} - \hat{\beta}_{FEM-SUR})\bar{X}_i \tag{16}$$

Step 9: Randomly resample with replacement from $\hat{u}_i$ to obtain u^*_i. Then compute

$$\pi^*_i = \hat{\gamma}_{POLS-SUR} Z_i + u^*_i \tag{17}$$

Step 10: Estimate the coefficients $\gamma^*_{POLS-SUR}$ using the starred data

Step 11: Repeat steps 5-9 1000 times and compute the sample standard deviation of $\gamma^*_{POLS-SUR}$ as an estimator of the standard error of $\hat{\gamma}_{POLS-SUR}$.

We then apply both the HT-3SLS-GMM and FEVD-SUR system approach to estimate the system of gravity equations for imports, exports, inward and outward FDI as:

$$\begin{aligned} log(EX_{ijt}) &= \alpha_0 + \alpha_1 + \alpha_2 log(GPD_{jt}) + \alpha_3 log(POP_{it}) \\ &\quad + \alpha_4 log(POP_{jt}) + \alpha_5 log(PROD_{it}) + \alpha_6 log(DIST_{ij}) \\ &\quad + \alpha_7 SIM + \alpha_8 RLF + \alpha_9 EMU \\ &\quad + \alpha_{10} EAST + \alpha_{11} BORDER + \alpha_{12} CEEC + \sum_{r=1993}^{2005} \alpha_r t_r, \end{aligned} \tag{18}$$

$$\begin{aligned} log(FDIout_{ijt}) &= \beta_0 + \beta_1 log(GDP_{it}) + \beta_2 log(GPD_{jt}) + \beta_3 log(POP_{it}) \\ &\quad + \beta_4 log(POP_{jt}) + \beta_5 log(PROD_{it}) + \beta_6 log(DIST_{ij}) \\ &\quad + \beta_7 log(WAGE_{jt}) + \beta_8 log(FDIopen_{jt}) + \beta_9 log(KF_{jt}) \\ &\quad + \beta_{10} SIM + \beta_{11} RLF + \beta_{12} EMU \\ &\quad + \beta_{13} EAST + \beta_{14} BORDER + \beta_{15} CEEC + \sum_{r=1993}^{2005} \beta_r t_r, \end{aligned} \tag{19}$$

$$\begin{aligned} log(IM_{ijt}) &= \gamma_0 + \gamma_1 log(GDP_{it}) + \gamma_2 log(GDP_{jt}) + \gamma_3 log(POP_{it}) \\ &\quad + \gamma_4 log(POP_{jt}) + \gamma_5 log(PROD_{jt}) + \gamma_6 log(DIST_{ij}) \\ &\quad + \gamma_7 SIM + \gamma_8 RLF + \gamma_9 EMU \\ &\quad + \gamma_{10} EAST + \gamma_{11} BORDER + \gamma_{12} CEEC + \sum_{r=1993}^{2005} \gamma_r t_r, \end{aligned} \tag{20}$$

$$
\begin{aligned}
log(FDIin_{ijt}) \quad = \quad & \delta_0 + \delta_1 log(GDP_{it}) + \delta_2 log(GPD_{jt}) + \delta_3 log(POP_{it}) \\
& + \delta_4 log(POP_{jt}) + \delta_5 log(PROD_{jt}) + \delta_6 log(DIST_{ij}) \\
& + \delta_7 log(KBLC_{it}) + \delta_8 SIM + \delta_9 RLF \\
& + \delta_{10} EMU + \delta_{11} EAST + \delta_{12} BORDER + \delta_{13} CEEC + \sum_{r=1993}^{2005} \delta_r t_r .
\end{aligned} \tag{21}
$$

Detailed variable descriptions and data sources are given in the appendix in table A.2. The use of time effects t_r is motivated by findings in Baldwin & Taglioni (2006). The authors show that an exclusion of such time effects may result in significant misspecifications, given the fact that it is often impossible to obtain trade- or FDI-specific price data. Moreover, time effects allow to control for business cycle effects over the sample period.

For both the IV and non-IV approach we apply the same estimation strategy: We first estimate the individual equations of the system in eq.(18) to eq.(21) and test for the cross-equation correlation of residuals, which may advocate the use of a full information approach. 'On the fly' this approach allows us derive a measure of the underlying trade-FDI linkages for our sample of German regions based on the 1.step estimates of the system's error term variance covariance matrix as pointed out by Egger & Pfaffermayr (2004). Taking the definition of Ω in the HT case as an example (see eq.(8)) the authors argue that the elements beside the main diagonal in $\hat{\Sigma}_\mu$ as estimates for the random state-country pair trade and FDI effects reflect the cross equation correlation between the unobservable individual effects for the respective trade and FDI equations. Thereby, a negative parameter sign indicates a substitutive relationship between the two after controlling for common and observed exogenous determinants. A similar logic applies to the variance covariance matrix of the error terms in the FEVD-SUR approach. The test setup suggested by Egger & Pfaffermayr (2004) may be seen as a straightforward extension to the standard approach to test for trade-FDI linkages, which typically employ simple pairwise residual correlations in an auxiliary regression (e.g. Graham, 1999, Brenton et al.,1999, Pantulu & Poon, 2003, Africano & Magalhaes, 2005, among others).

To check for the significance of the cross-equation residual correlation we use Breusch-Pagan (1980) type tests corrected for unbalanced panel data sets according to Song & Jung (2001) and Baltagi & Song (2006).[28] We define the latter BP-LM test as

[28] Rather than using one-sided Honda (1985) type tests as proposed by Egger & Pfaffermayr (2004), since the cross equation covariance elements can actually become negative.

$$BP = \left(\frac{1}{2}\right) n^2[A^2/(J-n)], \quad \text{with:} \quad J = \sum_{i=1,j=1}^{NM} T_{ij} \times (T_{ij} - 1), \tag{22}$$
$$A = [(u_j \Delta_1 \Delta_1' u_l)/((u_j' u_j)(u_l' u_l))^{1/2}],$$
$$\Delta_1 = (D_1', D_2', \ldots, D_T')',$$

where n is the number of total observations and D_t is obtained from an identity matrix I_{NM} by omitting the rows corresponding to individuals not observed in year t.[29] Under the null hypothesis of no correlation, the Breusch-Pagan type LM statistic given by eq.(22) is asymptotically distributed as $\chi^2(1)$.

Turning to the estimation output, table 7 plots the results for the Hausman-Taylor 3SLS-GMM estimator and table 8 reports the FEVD-SUR findings. We first give a short discussion of the obtained modelling results and postestimation tests and then turn to the discussion of trade-FDI linkages: The R^2 as an overall indicator for the model 'fit' shows that both estimators are quite close and explain a significant part of the total variation in the respective trade and FDI equations (around 50-70%). Taking a closer look at the variable coefficients, for the export equation income variables show a surprisingly low explanatory power and only turn out to be (weakly) significant and of expected coefficient sign in the FEVD-SUR approach. On the contrary, home productivity (defined as GDP per total employment) turns out to be significanlty positive for both the HT-3SLS-GMM and the FEVD-SUR, with the estimated elasticities bein almost identical in both specifications. From an economic point of view this result may hint at the strong correlation between labour productivity and export activity, which is broadly confirmed in the closely related firm-level based empirical New Trade Theory literature. With respect to home and foreign population both estimators get highly significant results with higher parameter values for the FEVD-SUR. Qualitatively both regression results give the same interpretation: Population abroad - and thus the potential market size - has a profound positive effect on German export activity. The negative coefficient of home population may either be interpreted in line with the self-sufficiency argument of increasing population size or alternatively with the dominance of capital intensive good exports in the composition of overall exports (as indicated by Serlenga & Shin, 2006), here the latter seems to be the more plausible line of argumentation from regional (SOE) perspective for German states.

[29] As Baltagi (2008) shows this can be easily done by restacking the residuals such that all the individuals observed in the first period are stacked on top of those observed in the second period, and so on. In this case, the slower index is t and the faster index is i, the error term (in vector form) can be written as $u = \Delta_1 \mu + \nu$. Testing for the cross-equation correlation of the overall error term, $\Delta_1 \Delta_1'$ chancels out (see e.g. Dufour & Kalaf, 2002).

For the bilateral interaction variables SIM and RLF the two models are again much in line: The negative coefficient for SIM indicates that trade among heterogeneous trading partners increases with overall export activitym, while RLF turns out to be insignificant in most specifications. The EMU dummy shows the a-priori expected positive impact on German exports for both estimators: That is, from 1999 onwards trade between Germany and the other EMU member states is estimated to be above its 'normal' potential (in terms of being adjusted for economic mass, geographical distance etc. as specified by the gravity model specification). Turning to the distance variables as a proxy for trade costs, in both model specifications the distance has the expected negative sign and is highly significant. For the HT model the coefficient exceeds the FEVD estimate, while the latter is more in range of the empirical literature. This result is also found in Mitze (2008), who shows on the basis of Monte Carlo simulation experiments that the Hausman-Taylor model tends to overestimate in particular the time-fixed variables coefficients, even if the C-Statistic of Eichenbaum et al. (1988) - as numerical difference for two overidentification tests in the spirit of Sargan (1958) / Hansen (1982) to check for the consistency of IV subgroups (or even single variables) rather than the whole instrument set - indicates that the variable is correlated with the unobservable individual effects and should thus be proxied by appropriate instruments (see e.g. the 1.step single equation post estimation tests in table A.3).[30]

As expected from previous research we also find a negative and highly significant coefficient for the dummy variable of the East German states indicating that the macro region is still far beyond their trading potential that we would expect according to their economic mass and their geographical location relative to its EU27 trading partners.[31] The results of the border and CEEC dummies are somewhat mixed: Both estimators find a positive but statistically insignificant coefficient for the border dummy,[32] while the HT model gets a (weakly significant) negative CEEC dummy whereas the FEVD output reports a positive coefficient sign. With respect to German exports to the CEECs the latter positive dummy variable coefficient indicates that trade flows to these countries are above the 'normal' potential, which we would expect based on their economic size and distance to German regions etc. This positive effect in CEEC trade has been widely confirmed in the earlier empirical studies based on trade data for the first half of the 90s,

[30]The difference between the two system approaches is already much smaller compared to the single equation benchmark models (for details see appendix).

[31]Related to our results Alecke et al. (2003) find a significant negative dummy variable for East German states in a gravity model context for estimating German regional trade flows to Poland and Czech Republic.

[32]A positive border effect may indicate that German regions, which share a common border with a neighbouring EU state, have considerably higher export relations with these countries than predicted as 'normal' by the gravity model (see e.g. Nitsch, 2000, for evidence on the EU).

which in turn speaks in favour of the FEVD-SUR estimation result.[33]

The interpretation of the estimation results for the other equations of our modelled trade-FDI-system is in similar veins: We find that output effects (both for the home and foreign country) proxying the role of 'economic mass' in bilateral trade and FDI activity play a much more distinct role than in the export equation in line with the theoretical gravity model assumptions, while foreign country productivity levels are found to be of reversed sign. In line with the export specification all equations assign a crucial role to geographical distance as an impediment to trade and FDI activity, while the effect is found to be higher in the FDI rather than trade case. The latter result may reflect the likely path dependency in building up FDI stocks, since the rather more distant 'pheripherical' EU member states states (from the geographical perspective of Germany) have only recently joint the EU (and thus adopted the institutional setup of the aquis communitaire). Moreover, the empirical findings that distance exerts a stronger negative impact on foreign affiliate production than exports can be related to similar results in the recent literature (see e.g. Braunerhjelm & Ekholm, 2000).

The positive coefficient sign of the interaction variable SIM (reflecting cross-country similarities) in the outward FDI equation supports our impression that German FDI activity within the EU27 is of a rather horizontal type. The interpretation of the SIM coefficient of the import equation is in line with the export case, while for inward FDI the variable turns out to be statistically insignificant in almost all specifications. We also find only weak empirical support for the proxy of relative factor endowments RLF, which is only significant in the import equation (both for the HT and FEVD estimator) and its positive coefficient sign indicates that inter industry type import flows dominate. The inclusion of the set of endowment base variables in the FDI equations (including the host country wage rate, as well as proxies for FDI agglomeration forces) shows mixed results: Foreign country wage levels are only found to be statistically significant in the FEVD-SUR model. The positive coefficient sign hints at the importance of high-skilled employment in FDI activity rather than (low) cost labour, which in turn supports our view of dominating horizontal FDI activities between German states and EU member countries. Positive FDI agglomeration effects (e.g. proxied by total stock of FDI relative to GDP in the host country) are estimated for both model specifications, though only in the Hausman-Taylor

[33] It remains an open discussion though whether this result is also expected to hold for the rapid economic catching up process of the CEECs. Further, it is also not clear whether Germany is able to hold its 'first mover'-advantages compared to the other EU15 countries: While Kunze and Schumacher (2003) predict a further boost in the German CEEC trade, Buch & Piazolo (2000) and Caetano et al. (2002) make projections based on gravity models that Germany throughout the 1990s has already exploited most of its trade potential with CEE countries, and that in the following other EU15 member states are expected to benefit most from the recent EU enlargement.

case they turn out to be statistically significant.

Opposed to the export equation the effect of the EMU on outward FDI is found to be negative, possibly reflecting the general trend of stagnating or even decreasing German FDI stocks in the EMU countries contrary to non-EMU economies within the EU27 (especially a shift from the pheripherical, southern mediteranean EMU member states to the CEECs throughout the late 1990s). On the contrary for inward FDI we find investment enhancing effects of EMU creation in line with the trade case. Thereby the results are found to be robust for both the HT and FEVD estimator. The dummy variables for the East German states and CEEC economies turn out to be strongly negative in most specifications. As in the export equation, for outward FDI the East German states dummy is found to be significantly negative. On the contrary, for inward FDI equation both estimators find a significant and positive dummy variable coefficient. This result mirrors the qualitative findings from our stylized facts representation that the East German states throughout their economic transition process are limited to act as an FDI host country with little options for actively invest abroad. Moreover, the positive coefficient for the East German macro region in the inward FDI equation may reflect the large-scale investment promotion scheme for the East German economy jointly launched by the EU, federal and state level government, which significanlty lowered the regional user costs of capital and led to an inflow of (foreign and West German) capital. The persistently negative CEEC dummy reflects our a-priori expectations that these countries - due to historical and structural reasons - still have very limited capacities to invest abroad. With respect to the border dummy we do not find any statistically significant result for both estimators.

<< insert Table 7 and 8 about here >>

Turning to the postestimation test results we first check for the robustness and appropriateness of our applied system estimators (with a particular focus on IV estimation), which may also allow to discriminate among the two rival approaches. For the Hausman-Taylor case we therefore employ different consistency and IV relevance tests in order to gain inside into any estimation bias and weak instrument problem. In table 7 we plot results of a 'weak identification' test to measure the degree of instrument correlation with the endogenous regressors to identify low correlation levels, which may translate into a poor overall performance (see e.g. Stock & Yogo, 2005). Here we employ the Kleinbergen-Paap Wald F-statistic as a robust generalization of the standard Cragg-Donald-based weak identification test when residuals are not necessarily i.i.d.[34] Unless not explicitly stated we compare the test results with the Staiger & Stock (1997) rule of thumb, that instruments are supposed to be deemed weak if the Kleinbergen-Paap Wald F-statistic is less than 10. For the HT-3SLS-GMM model all equations pass the weak identification test.

Next we use the commonly applied Sargan (1958) / Hansen (1982) test for overidentification of moment conditions. In an overidentified model the latter allows to test whether the IV set does not satisfy the orthogonality conditions required for their employment, while a rejection casts doubts on the instrument choice.[35] The results of the overidentification test indicate that except for the inward FDI model all equations have rather low test statistics.[36] For IV selection we thereby mainly base our modelling strategy on a downward testing approach, which centers around the C-Statistic as numerical difference of two Sargan overidentification tests (for details on IV selection algorithms in the HT case see also Mitze, 2008). However, for the inward FDI equations all attempts to further reduce the number of moment conditions above those reported in table 7 result in a break down of most variable coefficients. Though some caveates may apply, in the latter equation we rely on the reported IV set even though it fails to pass the Sargan overidentification test for convenience confidence intervals.

To compare the appropriateness of our chosen system approach relative to a limited information (single equation) benchmark, which builds on a block diagonal variance-covariance matrix (as in standard equation-by-equation 2SLS), we employ the Hausman (1978) m-statistic defined as:

$$m = \hat{q}'(\hat{Q} - \hat{V})^{-1}\hat{q}, \tag{23}$$

where $\hat{q} = \hat{\beta}_{3SLS} - \hat{\beta}_{2SLS}$ is the difference between the 3SLS and 2SLS estimators of the same parameter in the Hausman-Taylor model, $\hat{Q}$ and $\hat{V}$ denote consistent estimates of the asymptotic covariance matrices of $\hat{\beta}_{3SLS}$ and $\hat{\beta}_{2SLS}$ respectively. The m-statistic has a χ^2 distribution with degrees of freedom equal to the number of parameter estimates. The underlying idea of the test is quite simple: Under the assumption that the 3SLS estimator

[34] We use the *ivreg2* Stata routine by Baum et al. (2007) to compute the test results.

[35] Assuming that the 'No Conditional Heteroscedasticity' NCH-condition holds, we employ the Sargan (1958) version of the test statistic, which can be easily calculated by regressing the residuals of the IV regression on the full instrument set. The Sargan Statistic then has an nR_u^2 form, where R_u^2 is the uncentered R-squared and n is the total number of observations. Since the model fit increases with a higher correlation of the residuals and the instrument set, this signals doubts for the validity of the model's underlying orthogonality assumptions.

[36] Since the overidentification test tends to be very restrictive in terms of hypothesis rejection, we take tests results for which the null hypothesis of instrument appropriateness is not rejected at the 1% level in favour for the respective IV set in focus.

is generally more efficient than the 2SLS estimator, we test whether the difference between the two estimators is large, indicating that the more complex GLS transformation in the 3SLS case is likely to induce a misspecification in the model rendering it inconsistent. Thus, under the null hypothesis both estimators are consistent, but only $\hat{\beta}_{3SLS}$ is efficient. Under the alternative hypothesis only $\hat{\beta}_{2SLS}$ is consistent.[37] For the FEVD model we use an analogous test framework comparing the SUR approach with the OLS benchmark. The results of the Hausman m-statistic in table 7 and table 8 show that the full information techniques (both in the HT and FEVD case) pass the test for convenient confidence intervals in all equations except for import flows. In sum we take these results in favour for our specified full information estimators.

In the spirit of Baltagi et al. (2003) we also employ a second Hausman test to check for the consistency and efficiency of the HT-3SLS-GMM estimator against the FEVD-SUR benchmark. The underlying idea in Baltagi et al. (2003) is to compare the Hausman-Taylor model results with the FEM benchmark for the parameter vector of time-varying variables. Thereby the null hypothesis states that both estimators are consistent, while the Hausman-Taylor approach is likely to be more efficient since it employs more information in the estimation setup. Under the alternative hypothesis only the FEM model is a consistent model choice. Since the FEVD equals the FEM for the parameters of the time-varying variables we can employ the test proposed by Baltagi et al. (2003) analogoulsy here. However, the Hausman m-statistic can not discriminate among the parameter vector of time-fixed variables since no general ex-ante hypothesis about parameter consistency and efficiency can be stated. Thus, we have to be somewhat cautious when interpreting the results as an ultimate model discrimination test.

The results of the second Hausman test for the vector time-varying variables in the HT and FEVD model are reported in table 8. The results indicate that the difference between the two estimators is rather small for the import and inward FDI equation, where the null hypothesis of consistency and efficiency of the HT model cannot be rejected for convenient confidence intervals. However, for the export and outward FDI equation the null hypothesis is clearly rejected. Thus, taken together with the empirical findings in Mitze (2008) that Hausman-Taylor type models tend to have a severe bias in estimating the coefficient vector of time-fixed variables, as an overall judgement we tend to favour the FEVD-SUR approach for our empirical application. We believe that the FEVD approach is generally less sensitive to likely problems in IV selection as reported for the inward

[37]By construction, if the 2SLS variance is larger than the 3SLS variance, the test statistic will be negative. Though the original test is typically not defined for negative values, here we follow Schreiber (2007) and take the absolute value of the m-statistics as indicator for rejecting the null hypothesis of 3SLS efficiency.

FDI equation in the HT case, which makes it the more robust and appropriate choice for a system estimator of our trade-FDI model. Finally, as indicated by the residual based ADF-test for cointegration in the spirit of Kao (1999), for both models we can reject the null hypothesis for non-stationarity in the residuals so that - taken together with the panel unit root tests from above - we are not running the risk of having spurious regression results in our model specifications.

Turning to the analysis of the underlying trade-FDI linkages in our system approach, we find significant cross-equation residual correlations for both estimator, which not only open up the possiblity to exploit additional gains in estimation efficiency (see Greene, 2003) but also to interpret the corresponding error term variance-covariance matrices in terms of cross-variable linkages (in the spirit of Egger & Pfaffermayr, 2004). Given the postestimation results from above here we rely on the FEVD-SUR results, which however are qualitatively broadly in line with the Hausman-Taylor results.[38] In table 9 we plot the corresponding (rank) correlation coefficients for our 4-equation residual variance-covariance matrix together with the Breusch-Pagan LM test results for unbalanced data. Additionally, we also compute Harvey-Phillips (1982) type exact independence F-test, which checks for the joint significance of the other equations' residuals in an augmented 1.step regression (see e.g. Dufour & Kalaf, 2002, for details).

<< insert Table 9 about here >>

The test results for the whole sample (including all German regions with their EU27 partner countries) show that we find significant evidence for both substitutive and complementary linkages among the variables under observation. Focusing on each type of international activity separately, for both the ex- and imports as well as outward and inward FDI activity respectively we observe complementary (enhancing) effects. Turning to the trade-FDI linkages we find a substitutive relationship between exports and outward FDI activity in line with earlier evidence in Jungmittag (1995) as well as Egger & Pfaffermayr (2004). Also, imports and outward FDI are found to be of substitutive nature. However, on the contrary imports and inward FDI are found to complement each other, while the relationship between exports and inward FDI is tested insignificantly on the basis of Breusch-Pagan LM tests. As a sensitivity analysis we then also estimate trade-FDI linkages for sub-aggregates of our data set as:

[38] Detailed results for the latter can be obtained upon request from the authors.

- West Germany - EU27,
  - West Germany - EU15,
- East Germany - EU27,
  - East Germany - EU15.[39]

Our motivation for doing so is that our data sample from 1993-2005 covers the transformation period of the central and eastern European countries (including also the East German economy) from planned to market economies. Given the historical situation of these countries, we only observe a gradually opening up for internationalization activity with the core EU-15 member states over the sample period, which may well impact on the empirical results. We thus expect that trade-FDI ties are supposed to be strongest for the West German states with their respective EU-15 bilateral country pairs.

If we start looking at the West German trade and FDI activity within the total EU27 in table 10 we see that the identified cross-equation residual correlations closely follow the predictions of New Trade theory models as in Baldwin & Ottaviano (2001): That is, when international trade is merely of intra industry type with non-zero trade costs, the latter shift production abroad and lead to export replacement effects of FDI. However, at the same time FDI may stimulates trade via reverse good imports. We thus find that export and outward FDI activity are still substitutes, however all remaining trade-FDI links show complementary effects. In the model of Baldwin & Ottaviano (2001) this result is mainly driven by cross-hauling of FDI generating reciprocal trade effects in differentiated final products. Given the dominance of horizontal trade between West Germany and the EU27 member states as well non-zero trade costs (as tested in our gravity model), these theoretical predictions may be seen as a good explanation for our empirically identified trade-FDI nexus in the case of West Germany.

Moreover, a further disaggregation to West German - EU15 trade and FDI activity in table 11 even reveals complementaries among export and FDI activity, which have not been identified for German data before, but generally match the mainstream empirical evidence in an international context. For the results of the East German macro region in table 12 and 13 we find merely substitutive linkages (except for inward FDI and trade in the East German - EU15 case), which may hint at the rather low level of internationalization activities (in particular outward FDI) of the East German macro region. Thus, to sum up in addition to recent findings supporting the need of a sectoral disaggregation in analysing trade-FDI linkages (e.g. Pfaffermayr, 1996, Bloningen, 2001, Türkcan, 2008),

[39] A further disaggregation does not seem feasible due to data limitations.

our results show that also the regional perspective within national trade and FDI activity may be of great importance in identifying cross-variable linkages.

<< insert Table 10 to 13 about here >>

6 Conclusion

Throughout this paper we have conducted an empirical investigation to identify the main macroeconomic driving forces for German (regional) trade and FDI activity within the EU27 and to identify their main trade-FDI linkages. Our analysis is particularly motivated by the fact that the relationship between trade and FDI has been of continuing interest both in the academic literature as well as in the policy debate. Our analysis hence builds on a huge stock of empirical contributions in the field: Though empirical evidence tends to be country specific, the majority of studies so far supports the view of a rather complementary relationship between trade and FDI. However, Jungmittag (1995) as well as Egger & Pfaffermayr (2004) were among the first to report negative export and outward FDI linkages for Germany.

Our analysis takes up the idea of Egger & Pfaffermayr (2004) to identify trade-FDI linkages 'on the fly' in subsequent modelling steps of a full information estimation stragegy for a simultaneous equation trade-FDI system. We thereby focus on German regional im- and export, as well as in- and outward FDI activity. From a methodological point of view we apply both IV and non-IV approaches to the analysis of our simultaneous equation trade-FDI model with panel data. Using a gravity model framework the estimation results show that trade and FDI variables are mainly influenced by the same set of variables assigning a prominent role to trade/FDI enhancing factors such as the economic mass of the countries (typically measured by variables derived from GDP and population levels) and obstacles to trade/FDI activity such as transportation costs (proxied by the geographical distance between two countries). The latter variable has been of special interest in the (New) trade theory literature and our findings suggest a stable negative impact of distance on both trade and FDI variables. Regarding the chosen econometric setup our results slightly favour the non-IV FEVD-SUR approach (based on the Fixed Effects Vector Decomposition model recently proposed by Plümper & Tröger, 2007) compared to a Hausman-Taylor type IV model.

In specifying a simultaneous equation model we finally can make use of the underlying error term variance-covariance matrix to identify the major trade-FDI linkages for German (regional) data. We get empirical support for both substitutive and complementary relationships among the variables under observation. First, focusing on each type of international activity separately, for both the ex- and imports as well as outward and inward FDI activity we generally observe complementary effects. Turning to the trade-FDI linkages we find a substitutive relationship between exports and outward FDI activity in line with earlier evidence in Jungmittag (1995) as well as Egger & Pfaffermayr (2004). Also, imports and outward FDI are found to be of a substitutive manner. However, on the contrary imports and inward FDI are found to complement each other, while the relationship between exports and inward FDI was tested statistically insignificant.

We then also estimate trade-FDI linkages for several sub-groups of our data set: For West German trade/FDI activity within the EU27 we find the that cross-equation residual correlation closely follows the predictions of New Trade theory models as in Baldwin & Ottaviano (2001): That is, when international trade is of merely intra industry type with non-zero trade costs, the latter shifts production abroad and lead to export replacement effects of FDI. However, at the same time FDI may stimulate trade via reverse good imports. Thus, export and outward FDI are found to be still substitutes for each other, while all remaining variable linkages show complementaries. Moreover, a further disaggregation into West German - EU15 trade/FDI activity even reveals complementaries among export and FDI activity, which have not been identified for German data before, but match the general empirical evidence in an international context. For the East German states we overwhelmingly find substitutive linkages (except for inward FDI and trade in the East German - EU15 case), which may indicate the rather low level of internationalization activities (in particular outward FDI) of the East German macro region. The identified trade-FDI linkages can finally be summarized as follows:

Germany - EU27

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	*			
FDI out	negative	*		
Imports	positive	negative	*	
FDI in	insign.	positive	positive	*

West Germany - EU27

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	*			
FDI out	negative	*		
Imports	positive	positive	*	
FDI in	positive	positive	positive	*

West Germany - EU15

	Exports	FDI out	Imports	FDI in
Exports	*			
FDI out	positive	*		
Imports	positive	positive	*	
FDI in	positive	positive	insign.	*

East Germany - EU27

	Exports	FDI out	Imports	FDI in
Exports	*			
FDI out	negative	*		
Imports	positive	negative	*	
FDI in	negative	positive	negative	*

East Germany - EU15

	Exports	FDI out	Imports	FDI in
Exports	*			
FDI out	negative	*		
Imports	positive	negative	*	
FDI in	positive	negative	positive	*

As Aizenman & Noy (2006) point out, when interpreting these results we have to carefully link them to our chosen country sample and time period: That is, while our results seem plausible for intra-EU trade and FDI activity (where the latter in first places follows horizontal motives), a generalization with respect to worldwide trade-FDI activity has to be done with caution.[40] These caveats have to be taken into account when the model results are used in the very sensitive policy debate concerning export and/or FDI promotion schemes. Future research should therefore particularly focus on the question, how job market effects are associated with both outward FDI and export activity (see e.g. Becker & Muendler, 2006). Moreover, attempts should be made to link our macro type results with the related firm-level evidence analysing productivity differences and the subsequent choice of serving foreign markets (see e.g. Helpman et a., 2003, or Arnold & Hussinger, 2006, for the German case) in order to advise the design of appropriate public promotion schemes to exploit positive spillovers from internationalisation activity. Our results finally also indicate that it seem fruitful to explicitly incorporate the regional perspective in order to properly model trade and FDI patterns and to identify underlying cross-variable linkages.

[40] Even though German-EU27 trade and FDI pattern accounts for a large share of total trade and FDI activity. Moreover, using a world sample Cechella et al. (2008) recently found that world FDI is also mainly driven by horizontal motives.

From a methodological point of view future research effort may account for dynamic adjustment processes in the model specification (see e.g. Anderson & Hsiao, 1981, Arellano & Bond, 1991, or Blundell & Bond, 1998, for its theoretical basis) and also to switch the focus from the pure long-run analysis to incorporate short run dynamics. The latter has been made possible through recent major innovations in the field of panel error correction models (see e.g. Breitung & Pesaran, 2008, for an overview). These approaches then also open up the possibility of alternative modes of causality testing between the variables in focus as e.g. proposed by Bajo-Rubio & Montero-Munoz (2001) or Aizenman & Noy (2006) and thus call for robustness tests of our empirical results.

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Table 1: Summary of variables for estimation in the trade and FDI equations

Variable	Code	Trade Eqs.	FDI Eqs.	Expected Coef. sign
Gross domestic product in i/j	GDP (or $\frac{GDP}{POP}$)	X	X	(+) Trade/FDI activity increases with absolute higher income or welfare levels respectively (induced by higher supply and demand for differentiated varieties)
Population in i/j	POP	X	X	(+/–) with – = Self-sufficiency in production (resource endowments); alternatively Trade: += Δ share of labour intensive trade; FDI: + = market potential theory of FDI
Similarity index of ij	SIM	X	X	(+/–) Trade: + = Δ share of intraindustry trade; FDI: + = Δ share of horizontal FDI
Relative factor endowments of ij	RLF	X	X	(+/-) Trade: + = Δ share of interindustry trade; FDI + = Δ share of vertical FDI
Labour productivity in i/j	$PROD$	X	X	(+) New Trade Theory: More productive firms on average higher degree of internationalization (expected to be higher for FDI than Trade)
Euro area dummy	EMU	X	X	(+) Trade/FDI creating effect of single currency
Wage level in j	$WAGE$		X	(–) Indicator for vertical cost oriented FDI engagement (only in outward FDI equation)
FDI Openness in j	$FDIopen$		X	(+) Proxy for agglomeration forces at work (only in outward FDI equation)
Capital stock in j	KF		X	(+/–) with + = Agglomeration forces or – = Neoclassical view (H-O) of higher expected return for relatively scare production factor (only in outward FDI equation)
Per head Capital stock in i	$KBLC$		X	(+/–) with + = Agglomeration forces or – = Neoclassical view (H-O) of higher expected return for relatively scare production factor (only in inward FDI equation)
Geographical distance of ij	$Dist$	X	X	(+/–) Trade: – = Transportation costs as obstacles to trade; FDI: + = FDI as alternative to trade for increasing distances, alternatively: – = Increasing monitoring costs over longer distance, increasing cultural differences etc.
East German State Dummy	$East$	X	X	(+/–) A-priori unknown (possibly: – = Negative historical path dependency in East German internationalization process)
CEE Country Dummy	$Ceec$	X	X	(+/–) A-priori unknown (possibly: – = Negative historical path dependency in CEEC internationalization process)
Common Border Dummy	$Border$	X	X	(+) Positive neighbouring effect on trade/FDI due to historical, cultural and personal ties

Table 2: Fisher-type and Pesaran (2007) Panel unit root tests for variables in levels

	χ^2**-statistic (p-val.) of Fisher-type test** H_0**: Series non-stationary**	
Specification	Constant without trend	Constant and time trend
$Export_{ijt}$	813,08*** (0,00)	842,63*** (0,00)
$FDIout_{ijt}$	853,27*** (0,00)	687,85*** (0,00)
$Import_{ijt}$	1099,67*** (0,00)	821,67*** (0,00)
$FDIin_{ijt}$	602,89 (0,26)	579,81 (0,51)
GDP_{it}	1412,13*** (0,00)	1364,72*** (0,00)
GDP_{jt}	522,63 (0,96)	772,73*** (0,00)
POP_{it}	2744,13*** (0,96)	502,02 (0,99)
POP_{jt}	2171,32*** (0,00)	1160,79*** (0,00)
$PROD_{it}$	1224,90*** (0,00)	1669,38*** (0,00)
$PROD_{jt}$	413,19 (0,99)	827,45*** (0,00)
SIM_{ijt}	783,17*** (0,00)	1096,57*** (0,00)
RLF_{ijt}	565,87 (0,67)	1012,69*** (0,00)
$WAGE_{jt}$	554,41(0,78)	759,67***(0,00)
$FDIopen_{jt}$	628,54* (0,08)	233,97 (0,99)
KF_{jt}	2387,88*** (0,00)	804,83*** (0,00)
$KBLC_{jt}$	1609,78*** (0,00)	1084,10*** (0,00)
	$Z[t-bar]$ **(p-val.) for Pesaran (2007) CADF test** H_0**: Series stationary**	
Critical Vars.	Constant without trend	Constant and time trend
$FDIin_{ijt}$	25,78 (0,99)	24,56 (0,99)
GDP_{jt}	1,99 (0,97)	9,16 (0,99)
POP_{it}	0,95 (0,83)	11,47 (0,99)
$PROD_{jt}$	2,14 (0,98)	9,84 (0,99)
RLF_{ijt}	4,69 (0,99)	10,05 (0,99)
$WAGE_{jt}$	1,75 (0,96)	9,12 (0,99)
$FDIopen_{jt}$	8,20 (0,99)	14,45 (0,99)

Note: The tests have been performed using the *xtfisher* Stata-routine written by Merryman (2005) and the *pescadf* routine by Lewandowski (2007).

Table 3: Regional shares of German total and EU27 export and import values as well as outward and inward FDI stocks

	Export share				Import share			
	Av. 1993-99		Av. 2000-05		Av. 1993-99		Av. 2000-05	
	World	EU27	World	EU27	World	EU27	World	EU27
BW	20,02 %	17,75 %	19,80 %	17,91 %	14,28 %	14,05 %	15,90 %	15,82 %
BAY	18,22 %	17,92 %	19,43 %	18,62 %	16,03 %	16,47 %	16,90 %	16,76 %
BER	1,90 %	1,75 %	1,68 %	1,54 %	1,31 %	1,46 %	1,21 %	1,22 %
BRA	0,64 %	0,73 %	0,92 %	0,96 %	0,95 %	0,90 %	1,18 %	0,90 %
BRE	2,16 %	1,86 %	1,98 %	1,78 %	2,87 %	1,59 %	2,03 %	1,47 %
HH	3,04 %	3,06 %	3,95 %	4,03 %	7,80 %	5,32 %	7,69 %	5,64 %
HES	7,29 %	7,26 %	6,26 %	6,10 %	11,25 %	10,52 %	9,95 %	9,60 %
MV	0,38 %	0,32 %	0,48 %	0,48 %	0,34 %	0,49 %	0,40 %	0,47 %
NIE	9,26 %	9,94 %	9,29 %	10,07 %	7,98 %	8,37 %	9,02 %	8,89 %
NRW	24,79 %	26,33 %	22,43 %	24,02 %	26,61 %	28,48 %	24,50 %	26,34 %
RHP	5,63 %	5,86 %	5,14 %	5,32 %	4,17 %	4,64 %	3,53 %	4,23 %
SAAR	1,76 %	2,16 %	1,75 %	2,28 %	1,53 %	2,01 %	1,73 %	2,35 %
SACH	1,32 %	1,51 %	2,56 %	2,32 %	1,24 %	1,61 %	1,64 %	1,82 %
ST	0,66 %	0,71 %	0,96 %	1,12 %	0,61 %	0,68 %	0,93 %	0,80 %
SH	2,22 %	2,11 %	2,26 %	2,30 %	2,41 %	2,62 %	2,55 %	2,79 %
TH	0,70 %	0,75 %	1,08 %	1,15 %	0,62 %	0,79 %	0,85 %	0,90 %
Germany	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*
East*	*3,70 %*	*4,01 %*	*6,01 %*	*6,03 %*	*3,76 %*	*4,48 %*	*5,00 %*	*4,89 %*
West*	*94,40 %*	*94,24 %*	*92,31 %*	*92,43 %*	*94,93 %*	*94,07 %*	*93,79 %*	*93,89 %*

	Share of outward FDI stocks				Share of inward FDI stocks			
	Av. 1993-99		Av. 2000-05		Av. 1993-99		Av. 2000-05	
	World	EU27	World	EU27	World	EU27	World	EU27
BW	17,71 %	13,76 %	19,44 %	12,96 %	12,80 %	12,43 %	11,23 %	10,29 %
BAY	21,57 %	23,54 %	20,33 %	25,49 %	11,14 %	11,36 %	16,00 %	16,99 %
BER	2,09 %	2,59 %	0,89 %	1,04 %	3,06 %	3,39 %	3,78 %	4,14 %
BRA	0,13 %	0,13 %	0,04 %	0,06 %	0,66 %	0,94 %	0,59 %	0,67 %
BRE	0,29 %	0,45 %	0,11 %	0,16 %	1,13 %	1,36 %	0,82 %	0,88 %
HH	3,83 %	4,72 %	2,40 %	2,84 %	7,09 %	7,18 %	6,75 %	7,67 %
HES	17,91 %	18,02 %	20,60 %	14,64 %	22,98 %	17,32 %	20,77 %	16,65 %
MV	0,16 %	0,05 %	0,04 %	0,06 %	0,56 %	0,53 %	0,52 %	0,42 %
NIE	6,79 %	7,36 %	5,28 %	6,48 %	5,13 %	5,39 %	4,28 %	3,81 %
NRW	22,37 %	22,50 %	25,27 %	29,23 %	27,32 %	29,15 %	28,25 %	31,42 %
RHP	5,59 %	5,38 %	4,51 %	5,72 %	2,51 %	3,28 %	2,18 %	2,19 %
SAAR	0,54 %	0,81 %	0,29 %	0,43 %	0,72 %	1,23 %	0,48 %	0,56 %
SACH	0,07 %	0,03 %	0,23 %	0,06 %	0,73 %	0,59 %	0,63 %	0,39 %
ST	0,23 %	0,00 %	0,02 %	0,01 %	2,07 %	3,62 %	1,24 %	1,65 %
SH	0,62 %	0,57 %	0,42 %	0,52 %	1,66 %	1,56 %	1,99 %	1,96 %
TH	0,11 %	0,11 %	0,13 %	0,29 %	0,44 %	0,67 %	0,46 %	0,31 %
Germany	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*	*100 %*
East*	*0,69 %*	*0,32 %*	*0,46 %*	*0,48 %*	*4,45 %*	*6,34 %*	*3,45 %*	*3,43 %*
West*	*97,21 %*	*97,09 %*	*98,65 %*	*98,48 %*	*92,49 %*	*90,26 %*	*92,76 %*	*92,42 %*

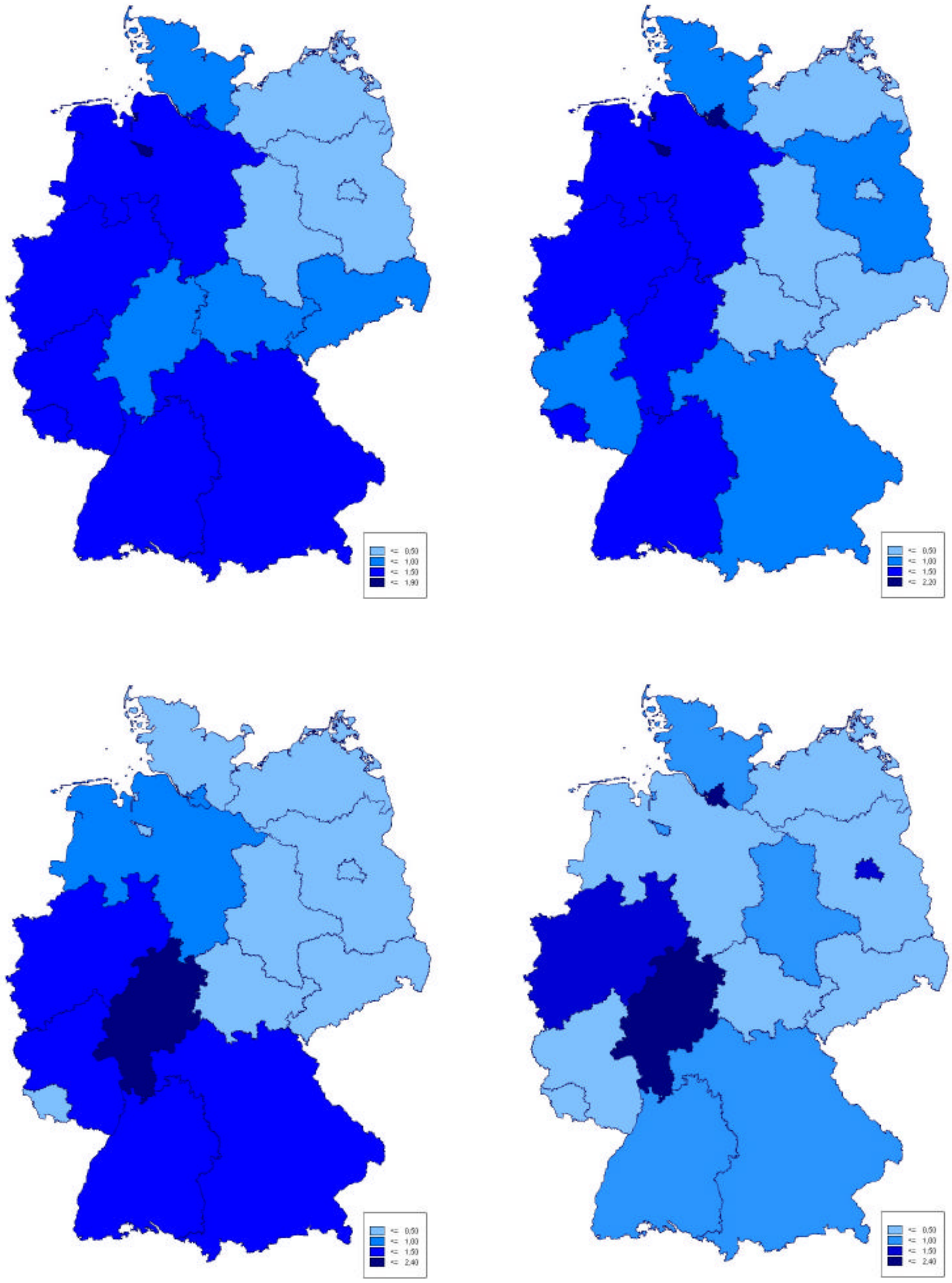
Note: BW = Baden-Wurttemberg, BAY = Bavaria, BER = Berlin, BRA = Brandenburg, BRE = Bremen, HH = Hamburg, HES = Hessen, MV = Mecklenburg-Vorpommern, NIE = Lower Saxony, NRW = North Rhine-Westphalia, RHP = Rhineland-Palatine, SAAR = Saarland, SACH = Saxony, ST = Saxony-Anhalt, SH = Schleswig-Holstein, TH = Thuringia.
*: East = East German states (excluding Berlin), West = West German states (excluding Berlin).
Source: Data from Statistisches Bundesamt (2007) and Deutsche Bundesbank (2007).

Table 4: Relative Export, import, outward and inward FDI intensity of German states compared to the national average (Germany = 1)

	Export intensity				**Import intensity**			
	Av. 1993-99		**Av. 2000-05**		**Av. 1993-99**		**Av. 2000-05**	
	World	EU27	World	EU27	World	EU27	World	EU27
BW	1,41	1,25	1,36	1,23	1,00	0,99	1,09	1,08
BAY	1,09	1,07	1,10	1,05	0,96	0,98	0,95	0,95
BER	0,46	0,42	0,46	0,42	0,31	0,35	0,33	0,33
BRA	0,31	0,35	0,42	0,44	0,46	0,44	0,54	0,42
BRE	1,97	1,70	1,83	1,64	2,62	1,45	1,87	1,36
HH	0,86	0,86	1,10	1,12	2,20	1,50	2,15	1,58
HES	0,82	0,82	0,71	0,69	1,27	1,19	1,12	1,08
MV	0,27	0,22	0,34	0,33	0,24	0,34	0,28	0,33
NIE	1,06	1,13	1,09	1,18	0,91	0,95	1,06	1,05
NRW	1,10	1,17	1,03	1,10	1,18	1,26	1,12	1,21
RHP	1,26	1,31	1,18	1,22	0,93	1,04	0,81	0,97
SAAR	1,43	1,76	1,47	1,91	1,25	1,64	1,45	1,97
SACH	0,36	0,41	0,68	0,61	0,33	0,44	0,43	0,48
ST	0,32	0,34	0,45	0,53	0,29	0,33	0,44	0,37
SH	0,69	0,66	0,73	0,74	0,75	0,82	0,82	0,90
TH	0,37	0,39	0,54	0,58	0,33	0,41	0,43	0,45
Germany	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*
East*	*0,33*	*0,36*	*0,52*	*0,52*	*0,34*	*0,40*	*0,43*	*0,43*
West*	*1,11*	*1,11*	*1,09*	*1,09*	*1,12*	*1,11*	*1,11*	*1,11*
	Outward FDI intensity				**Inward FDI intensity**			
	Av. 1993-99		**Av. 2000-05**		**Av. 1993-99**		**Av. 2000-05**	
	World	EU27	World	EU27	World	EU27	World	EU27
BW	1,24	0,97	1,33	0,89	0,90	0,87	0,77	0,70
BAY	1,29	1,41	1,15	1,44	0,67	0,68	0,90	0,96
BER	0,50	0,62	0,24	0,28	0,73	0,82	1,04	1,14
BRA	0,06	0,06	0,02	0,03	0,32	0,46	0,27	0,31
BRE	0,27	0,41	0,10	0,15	1,03	1,24	0,76	0,81
HH	1,08	1,33	0,67	0,80	2,00	2,02	1,89	2,15
HES	2,02	2,03	2,32	1,65	2,59	1,95	2,34	1,88
MV	0,12	0,03	0,03	0,04	0,39	0,37	0,37	0,29
NIE	0,77	0,84	0,62	0,76	0,59	0,61	0,50	0,45
NRW	0,99	1,00	1,16	1,34	1,21	1,29	1,29	1,44
RHP	1,25	1,21	1,04	1,32	0,56	0,73	0,50	0,50
SAAR	0,44	0,66	0,25	0,36	0,58	1,00	0,40	0,47
SACH	0,02	0,01	0,06	0,02	0,20	0,17	0,17	0,10
ST	0,11	0,00	0,01	0,00	0,97	1,70	0,59	0,78
SH	0,19	0,18	0,14	0,17	0,52	0,49	0,64	0,63
TH	0,06	0,06	0,06	0,15	0,23	0,35	0,23	0,15
Germany	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*	*1,00*
East*	*0,06*	*0,03*	*0,04*	*0,04*	*0,40*	*0,56*	*0,30*	*0,30*
West*	*1,15*	*1,15*	*1,16*	*1,16*	*1,09*	*1,07*	*1,09*	*1,09*

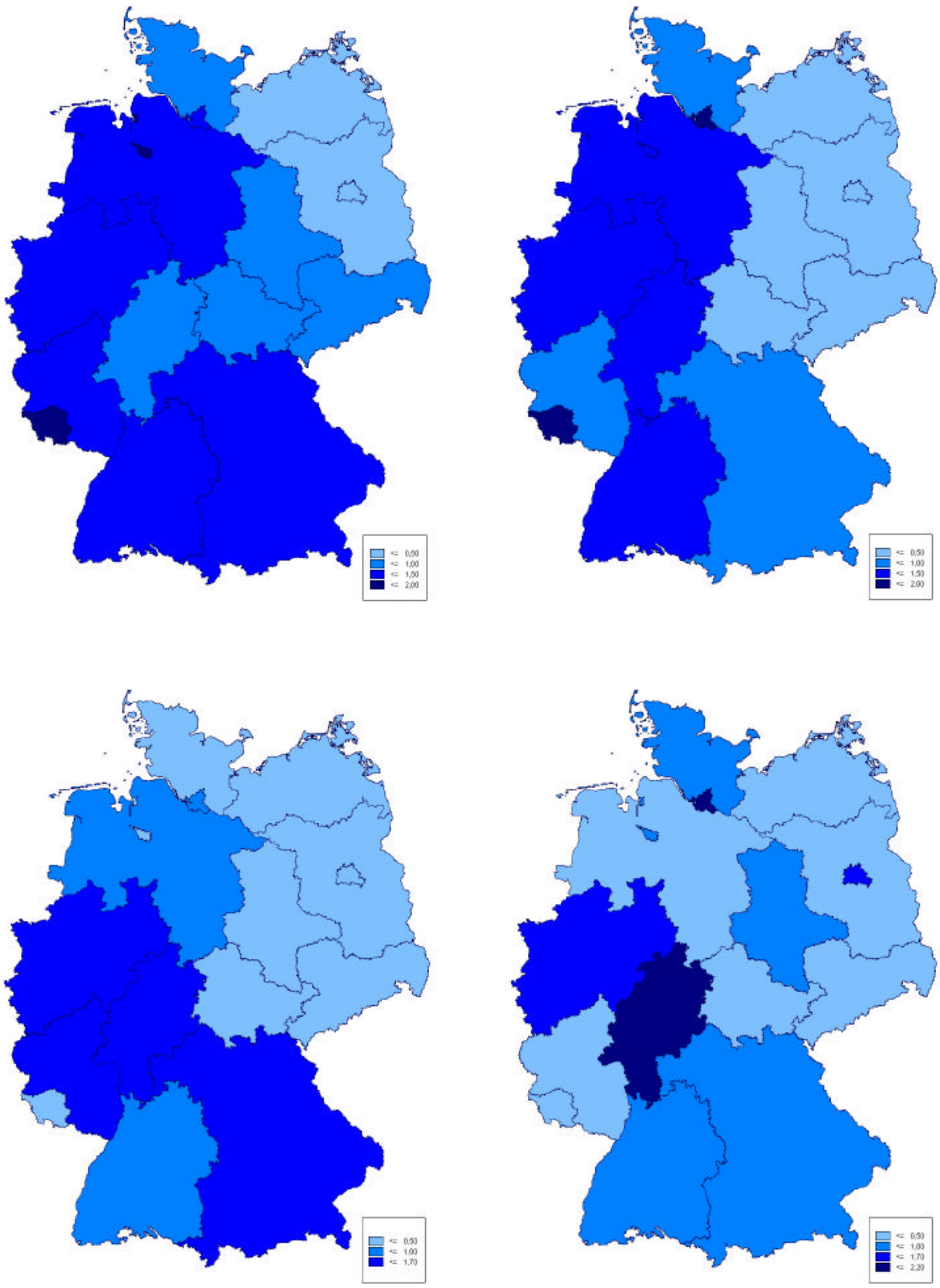
Note: BW = Baden-Wurttemberg, BAY = Bavaria, BER = Berlin, BRA = Brandenburg, BRE = Bremen, HH = Hamburg, HES = Hessen, MV = Mecklenburg-Vorpommern, NIE = Lower Saxony, NRW = North Rhine-Westphalia, RHP = Rhineland-Palatine, SAAR = Saarland, SACH = Saxony, ST = Saxony-Anhalt, SH = Schleswig-Holstein, TH = Thuringia.
*: East = East German states (excluding Berlin), West = West German states (excluding Berlin).
Source: Data from Statistisches Bundesamt (2007) and Deutsche Bundesbank (2007).

Figure 2: Total regional trade and FDI intensities for the average 2000-2005 (with upper left: Exports, upper right: Imports, lower left: outward FDI, lower right: inward FDI)



Source: See table 5 and table 6.

Figure 2: EU27 regional trade and FDI intensities for the average 2000-2005 (with upper left: Exports, upper right: Imports, lower left: outward FDI, lower right: inward FDI)



Source: See table 5 and table 6.

Table 7: 3SLS-GMM estimation results for Hausman Taylor model

	HT-3SLS-GMM			
Dep. Variable	Exports	FDI out	Imports	FDI in
$Log(GDP_i)$	0,94 (0.650)	5,11*** (1,777)	1,23** (0,503)	2,58*** (0,996)
$Log(GDP_j)$	0,12 (0,948)	0,93*** (0,242)	2,65*** (0,855)	5,56*** (1,085)
$Log(POP_i)$	-1,55** (0,769)	-3,35** (1,688)	-0,42 (0,533)	1,35* (0,781)
$Log(POP_j)$	0,58*** (0,146)	2,31*** (0,404)	-1,88** (0,858)	-6,49*** (1,177)
$Log(PROD_i)$	2,01*** (0,638)	-3,92** (1,904)		
$Log(PROD_j)$			-2,52*** (0,821)	-5,50*** (1,092)
$Log(DIST_{ij})$	-1,23*** (0,366)	-3,21*** (0,497)	-1,53*** (0,311)	-2,88*** (0,904)
$Log(WAGE_j)$		0,13 (0,271)		
$Log(FDIopen_j)$		0,49*** (0,131)		
$Log(KF_j)$		-0,95*** (0,344)		
$Log(\frac{KBL_i}{POP_i})$				-2,26*** (0,678)
SIM	-0,37*** (0,102)	1,24*** (0,349)	-0,69*** (0,248)	-0,52* (0,317)
RLF	0,01 (0,010)	0,01 (0,034)	0,07** (0,034)	-0,06 (0,041)
EMU	0,20*** (0,041)	-0,51*** (0,143)	0,04 (0,067)	0,57*** (0,164)
$EAST$	-0,79*** (0,203)	-2,98*** (0,475)	0,36 (0,282)	2,12*** (0,522)
$BORDER$	0,73 (0,590)	-1,22* (0,691)	0,29 (0,430)	-1,72 (1,399)
$CEEC$	-0,48* (0,285)	-3,15*** (0,533)	0,15 (0,359)	-3,99*** (0,629)
Time effects (P-value of Wald test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of system observation	10660			
No. of obs. per equation	2665	2665	2665	2665
No. of Groups per equation	353	353	353	353
KP Weak Ident. F-Test Staiger-Stock Rule ($F \geq 10$)	38,64 passed	85,12 passed	147,98 passed	21,98 passed
Hansen/Sargan Overid. (P-value)	8,67 (3) (0,04)	9,98 (4) (0,04)	8,53 (5) (0,12)	42,86 (3) (0,00)
$\lvert m\rvert - stat.$ **3SLS/2SLS** (P-value)	0,01 (0,99)	28,56 (0,43)	42,26 (0,01)	36,54 (0,08)
Resid. based ADF test (P-value)	766,4*** (0,00)	1113,5*** (0,00)	1579,9*** (0,00)	1327,0*** (0,00)
R^2	0,69	0,66	0,42	0,59

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. Standard errors are robust to heteroscedasticity and clustering on state-country pairs. Variable classification $X1 = [GDP^1_{jt}$, POP^1_{jt}, $PROD^1_{jt}$, POP^2_{jt}, POP^2_{it}, $PROD^2_{jt}$, $WAGE^2_{jt}$, KF^2_{jt}, GDP^3_{it}, GDP^3_{jt}, POP^3_{jt}, POP^3_{it}, $PROD^3_{jt}$, RLF^3_{ijt}, POP^4_{jt}, $PROD^4_{jt}$, $KBLC^4_{it}$, $RLF^4_{ijt}]$ and $Z2 = [DIST^1_{ij}$, $DIST^2_{ij}$, $DIST^3_{ij}]$ where high level indices indicate the different equations as 1=export, 2=outward FDI, 3=imports and 4=inward FDI. Endogeneity of $Z2$ is tested based on C-Statistic.

Table 8: FEVD-SUR estimation results

	FEVD-SUR			
Dep. Variable	Exports	FDI out	Imports	FDI in
$Log(GDP_i)$	0,62* (0,356)	4,50*** (1,263)	1,56*** (0,215)	1,57*** (0,572)
$Log(GDP_j)$	0,13** (0,056)	-0,85 (0,552)	1,35*** (0,177)	4,91*** (0,429)
$Log(POP_i)$	-1,57*** (0,527)	-1,30 (1,847)	-0,70 (0,455)	6,79*** (1,314)
$Log(POP_j)$	2,17*** (0,410)	-0,52 (1,440)	2,89*** (0,548)	-0,70 (1,345)
$Log(PROD_i)$	2,16*** (0,362)	-4,34*** (1,293)		
$Log(PROD_j)$			-1,12*** (0,191)	-5,22*** (0,467)
$Log(DIST_{ij})$	-0,79*** (0,051)	-1,71*** (0,189)	-1,16*** (0,068)	-2,99*** (0,165)
$Log(WAGE_j)$		1,22*** (0,453)		
$Log(FDIopen_j)$		0,05 (0,105)		
$Log(KF_j)$		-0,83** (0,422)		
$Log(\frac{KBL_i}{POP_i})$				1,61*** (0,431)
SIM	-0,33***	1,79*** (0,206)	-0,28*** (0,073)	0,03 (0,172)
RLF	0,01 (0,007)	0,02 (0,025)	0,04*** (0,009)	-0,06*** (0,022)
EMU	0,16*** (0,024)	-0,75*** (0,101)	-0,07** (0,035)	0,35*** (0,083)
$EAST$	-1,16*** (0,294)	-3,75*** (0,775)	-0,22 (0,341)	2,41*** (1,001)
$BORDER$	0,71 (0,411)	1,04 (0,968)	-1,10 (0,629)	0,90 (1,406)
$CEEC$	0,58** (0,293)	-5,53*** (0,826)	-1,14*** (0,393)	-6,34*** (1,207)
Time effects (P-value of Wald test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of system observation	10660			
No. of obs. per equation	2665	2665	2665	2665
No. of Groups per equation	353	353	353	353
$\|m\| - stat.$ **SUR/OLS** (P-value)	9,60 (0,97)	10,39 (0,98)	63,93 (0,00)	8,92 (0,98)
$\|m\| - stat.$ **HT-SYS/FEVD-SYS** (P-value)	115,15 (0,00)	117,98 (0,00)	20,14 (0,44)	15,36 (0,80)
Resid. based ADF test (P-value)	659,7** (0,01)	1418,5*** (0,00)	1185,8*** (0,00)	1027,4*** (0,00)
R^2	0,53	0,58	0,63	0,58

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. Standard errors are robust to heteroscedasticity, for a description of the wild bootstrap algorithm to adjust 2. step standard errors see text. The number of bootstrap repetitions is set to 1000.

Table 9: Cross-equation residual correlation and Breusch-Pagan significance test for aggregate German - EU27 trade/FDI

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	1,00			
FDI out	-0,44*** $\chi^2(1) = 71,9$	1,00		
Imports	0,53*** $\chi^2(1) = 95,5$	-0,15*** $\chi^2(1) = 8,69$	1,00	
FDI in	0,02 $\chi^2(1) = 0,12$	0,25*** $\chi^2(1) = 27,3$	0,41*** $\chi^2(1) = 62,1$	1,00
Harvey-Phillips (P-val.)	(0,00)	(0,00)	(0,00)	(0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively.

Table 10: Cross-equation residual correlation and Breusch-Pagan significance test for West German - EU27 trade/FDI

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	1,00			
FDI out	-0,16** $\chi^2(1) = 4,01$	1,00		
Imports	0,33*** $\chi^2(1) = 43,8$	0,19*** $\chi^2(1) = 24,2$	1,00	
FDI in	0,14*** $\chi^2(1) = 9,69$	0,35*** $\chi^2(1) = 53,7$	0,71*** $\chi^2(1) = 140,9$	1,00
Harvey-Phillips (P-val.)	(0,00)	(0,00)	(0,00)	(0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively.

Table 11: Cross-equation residual correlation and Breusch-Pagan significance test for West German - EU15 trade/FDI

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	1,00			
FDI out	0,30*** $\chi^2(1) = 49,7$	1,00		
Imports	0,66*** $\chi^2(1) = 124,5$	0,13*** $\chi^2(1) = 9,67$	1,00	
FDI in	0,10*** $\chi^2(1) = 7,80$	0,75*** $\chi^2(1) = 150,7$	-0,03 $\chi^2(1) = 0,33$	1,00
Harvey-Phillips (P-val.)	(0,00)	(0,00)	(0,00)	(0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively.

Table 12: Cross-equation residual correlation and Breusch-Pagan significance test for East German - EU27 trade/FDI

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	1,00			
FDI out	-0,48*** $\chi^2(1) = 67,6$	1,00		
Imports	0,80*** $\chi^2(1) = 161,2$	-0,44*** $\chi^2(1) = 58,4$	1,00	
FDI in	-0,56*** $\chi^2(1) = 113,8$	0,35*** $\chi^2(1) = 44,1$	-0,55*** $\chi^2(1) = 113,7$	1,00
Harvey-Phillips (P-val.)	(0,00)	(0,00)	(0,00)	(0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively.

Table 13: Cross-equation residual correlation and Breusch-Pagan significance test for East German - EU15 trade/FDI

	Exports	**FDI out**	**Imports**	**FDI in**
Exports	1,00			
FDI out	-0,44*** $\chi^2(1) = 75,5$	1,00		
Imports	0,77*** $\chi^2(1) = 168,9$	-0,45*** $\chi^2(1) = 74,6$	1,00	
FDI in	0,76*** $\chi^2(1) = 161,6$	-0,40*** $\chi^2(1) = 62,3$	0,69*** $\chi^2(1) = 152,9$	1,00
Harvey-Phillips (P-val.)	(0,00)	(0,00)	(0,00)	(0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively.

Appendix

A The Hausman-Taylor estimator (for unbalanced panel data)

In the following we briefly sketch the Hausman-Taylor (1981) estimation approach. For a general discussion see e.g. Baltagi (2008). Our approach here closely follows Gardner (1998) and Baltagi & Chang (2000), who propose an estimation strategy for unbalanced panel data. Basically, the HT model may be seen as a hybrid version of the Fixed Effects (FEM) and Random Effects Model (REM), which avoids the strong 'all or nothing' assumption of the above two estimators in terms of right hand side variable correlation with the composed error term of the model. The main idea of the HT approach is to set up an IV regression only based on instruments from internal data transformations so that no additional external information is necessary to estimate the whole parameter set by IV technique.

In doing so, starting from eq.(3) the Hausman-Taylor approach splits the set of time varying variables into two subsets $X_{ijt} = [X1_{ijt}, X2_{ijt}]$, where the $X1$ variables are supposed to be exogenous with respect to both error components, that is the unobservable individual effects (μ_{ij}) and the remainder error term (ν_{ijt}), while the $X2$ variables are assumed to be correlated with (μ_{ij}) and thus endogenous.[41] The same classification is also done for the set of time invariant variables $Z_{ij} = [Z1_{ij}, Z2_{ij}]$. The resulting model can be written as:

$$y_{ijt} = \alpha + \beta_1' X1_{ijt} + \beta_2' X2_{ijt} + \gamma_1' Z1_{ij} + \gamma_2' Z2_{ij} + u_{ijt}, \text{ with: } u_{ijt} = \mu_{ij} + \nu_{ijt} \qquad (24)$$

The presence of $X2$ and $Z2$ is the cause of the bias in the standard REM. In the model, group means of the exogenous time-varying variables $X1$ are then used as consistent instruments for estimating the time invariant endogenous coefficients $Z2$. Deviations from individual means of $X1$ and $X2$ are used as instruments for $X1$ and $X2$ (in the logic of the FEM estimator), while $Z1$ are used as their own instruments. Both the FEM and REM can be derived as a special form of the HT model, namely when all regressors are correlated with the individual effects the model reduces to the FEM. For the case that all variables are exogenous (in the sense of no correlation with the individual effects) the model takes the REM form.

[41] Here we use the terminology of 'endogenous' and 'exogenous' to refer to variables that are either correlated with the unobserved individual effects μ_i or not. An alternative classification scheme used in the panel data literature classifies variables as either 'doubly exogenous' with respect to both error components μ_i and $\nu_{i,t}$ or 'singly exogenous' to only ν. We use these two definitions interchangeably here.

In empirical terms the HT model is estimated by generalized least squares (GLS). We therefore first have to estimate the untransformed model in eq.(24) by standard IV techniques (2SLS) and then take the regression residuals $\hat{u}$ to derive the GLS correction factor θ_{ij}, which is based on consistent estimates of the variances (σ^2) of μ_{ij} and ν_{ijt} as:

$$\theta_{ij} = 1 - \sqrt{\frac{\hat{\sigma}_\nu^2}{\hat{\sigma}_\nu^2 + T_{ij}\hat{\sigma}_\mu^2}}, \text{ with:} \tag{25}$$

$$\hat{\sigma}_\nu^2 = \frac{(\hat{u}'Q\hat{u})}{\sum_{i=1,j=1}^{NM}(T_{ij}-1)} \text{ and} \tag{26}$$

$$\hat{\sigma}_\mu = \frac{(\hat{u}'P\hat{u}) - (NM\hat{\sigma}_\nu^2)}{\sum_{i=1,j=1}^{NM} T_{ij}}, \tag{27}$$

where Q is an operator transforming a variable into its deviations from group means, while P produces group means of a variable. P for each pair is defined as $J_{T_{ij}}/T_{ij}$, where $J_{T_{ij}}$ is an $(T_{ij} * T_{ij})$ matrix of ones. Q is defined as $I_{T_{ij}} - P$, where $I_{T_{ij}}$ is an identity matrix of dimension T_{ij}.

Different to the balanced case for unbalanced data the GLS factor θ_{ij} depends on the numbers of time observations for each country pair ij, where the correction in unbalanced data settings is necessary to control for heteroscedasticity in the GLS factor θ_{ij}. We then apply the GLS transformation on the all variables and IVs resulting in a generalized instrumental variable (GIV) type estimator.[42] The GLS transformation is generally necessary to ensure consistency and efficiency of the estimator. The transformed model can be written as:

$$\tilde{y}_{ijt} = \tilde{\alpha} + \beta_1'\widetilde{X1}_{ijt} + \beta_2'\widetilde{X2}_{ijt} + \gamma_1'\widetilde{Z1}_{ij} + \gamma_2'\widetilde{Z2}_{ij} + \tilde{u}_{ijt}, \tag{28}$$

where $\tilde{y}$ denotes the following transformation for a variable $\tilde{y}_{ijt} = y_{ijt} - \theta_{ij}\bar{y}_{ij.}$, with $\bar{y}_{ij.} = \frac{1}{T}\sum_{t=1}^{T} y_{ijt}$. This so-called quasi-differencing approach is equivalent to multiplying eq.(3) with $\Omega_{ij}^{-1/2}$, where $\Omega_{ij} = Cov(u_{ijt} \mid X_{ijt}, Z_{ij})$ is the covariance matrix of eq.(3) for the single equation case. Since its calculation depends of the number of time observations (T_{ij}), for the unbalanced case also Ω changes for each country pair ij as:[43]

[42]One has to note that the HT model can also be estimated based on a slightly different transformation, namely the filtered instrumental variable (FIV) estimator. The latter transforms the estimation equation by GLS but uses unfiltered instruments. However, both approaches typically yield similar parameter estimates. See Ahn & Schmidt (1999) for details. In the following we focus on GIV estimates.

[43]In fact, Gardner (1998) shows that using $\Omega_{ij}^{-1/2} = \frac{1}{\sigma_\nu}[Q + (1-\theta_{ij})P]$ to transform the estimation equation by pair as

$$\Omega_{ij} = \sigma^2_\nu Q + (\sigma^2_\nu + T_{ij}\sigma^2_\mu)P. \tag{31}$$

In both stepts the model is based on the IV set as $A_{HT} = [QX1, QX2, (1-\theta_{ij})PX1, (1-\theta_{ij})Z1]$.[44] Finally, the important order condition for the HT estimator is $k_1 \geq g_2$. That is, the total number of time-varying doubly exogenous variables k_1 that serve as instruments has to be at least as large as the number of time invariant singly exogenous variables (g_2). For the case that ($k_1 > g_2$) the equation is said to be overidentified and the HT estimator obtained from a 2SLS regression is more efficient than the within estimator (see also Baltagi, 2008).

A crucial point in applied work is to decide about the proper variable classification in terms of $X1/X2$ and $Z1/Z2$ variables for consistent IV selection. Hausman & Taylor (1981) them self suggest the use of economic intuition in this modelling step, which however may not be an optimal strategy in the absence of strong ex-ante assumption. An alternative strategy is therefore to rely on statistical testing for overidentifying restrictions. Here the most common approach is to apply the Sargan (1958) / Hansen (1982) test, which has the joint null hypothesis that the instruments are valid instruments as being uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as ^{2}-squared in the number of overidentifying restrictions. A rejection of the null casts doubt on the validity of the chosen IV set. In the case that the 'No conditional heteroscedasticity' (NCH) assumption holds, the test statistic takes the Sargan (1958) form typically calculated as nR^2 from a regression of the IV residuals on the set of instruments. In a recent Monte Carlo simulation based comparison of the Hausman-Taylor IV approach with non-IV rival estimators Mitze (2008) however shows that an IV selection strategy which is solely based on statistical testing procedures in terms of the Sargan (1958) statistic may lead to biased results - especially for time-fixed variable coefficients.

$$\Omega_{ij}^{-1/2} = \Omega_{ij}^{-1/2}\beta' X_{ijt} + \Omega_{ij}^{-1/2}\gamma' Z_{ij} + \Omega_{ij}^{-1/2}\mu_{ij} + \Omega_{ij}^{-1/2}\nu_{ijt} \tag{29}$$

yields e.g. with respect to y:

$$[Q + (1-\theta_{ij})P]y_{ijt} = (y_{ijt} - y_{ij.}) + (1-\theta)y_{ij.} = y_{ijt} - \theta_{ij}y_{ij.} \tag{30}$$

[44] For details see e.g. Wooldridge (2002). On has further to note that this set of instruments is based on the HT interpretation of Breusch et al. (1989). Another difference from the balanced case is that we also transform the instruments $PX1$ and $Z1$ by the GLS factor. As Gardner (1998) argues, for balanced data the GLS factor is constant over time so that an omission is inconsequential when computing the means of the instruments. For the case of unbalanced data the omission of θ_{ij} is somewhat problematic because θ_{ij} weighted means are not constant across pairs. Among the few empirical applications of the modified HT estimator for unbalanced panel data is given by Goaied & Ayed-Mouelhi (2000).

B Fixed Effects Vector Decomposition (FEVD) estimator

An alternative to the Hausman-Taylor IV-estimator is an augmented FEM approach proposed by Plümper & Tröger (2007).[45] The goal of the so-called Fixed Effects Vector Decomposition (FEVD) model is to run a consistent FEM model and still get estimates for the time-invariant variables. The intuition behind FEVD specification is as follows: The unobservable individual effects are a vector of the mean effect of omitted variables, including the effect of time-invariant variables. According to Plümper & Tröger (2007) it is therefore possible to regress the proxy for individual effects derived from the FEM residuals on the time-invariant variables to obtain approximate estimates for these variables. Using this information the FEVD estimator for a general panel data model as in eq.(3) is basically specified based on the following three steps: First, we run a standard FEM to obtain the vector of time-varying variable β. Second, we use the estimated vector of group residuals as proxy for the unobservable individual effects $\hat{\mu_{ij}}$ to run a regression of the explanatory time-invariant variables against this 'generated regressand' as:

$$\hat{\mu}_{ij} = \omega + \hat{\delta}' Z_{ij} + \eta_{ij}, \tag{32}$$

where ω is the intercept of the second stage regression and η_{ij} is the residual. The second step aims at identifying the unobserved parts of the individual effects. In a third (optional) step the FEVD approach then re-estimates eq.(3) in a POLS setup including the 2. step residual η_{ij} to control for collinearity between time-varying and time-fixed right hand side variables as

$$y_{ijt} = \alpha + \beta' X_{ijt} + \gamma' Z_{ij} + \eta_{ij} + \xi_{ijt}. \tag{33}$$

Finally, it is important that standard error for the time-fixed variable coefficients have to be corrected due to the use of a 'generated regressand' in the 2. modelling step to avoid an overestimation of t-values. To sum up, the FEVD 'decomposes' the estimated proxy for the unobservable individual effects obtained from the FEM residuals into one part explained by the time-fixed variables and a remainder error term. Plümper & Tröger argue that one major advantage of the FEVD compared to the Hausman-Taylor model is that there is no need for any arbitrary ex-ante variable classification for consistent IV selection, since the standard FEVD approach relies on robust OLS estimation.

However, as shown in Mitze (2008) although the researcher is not confronted with the choice of classifying variables as being exogenous or endogenous with respect to the error

[45] The FEVD model may be seen as an extension of a model of Hsiao (2003). For details see Plümper & Tröger (2007).

term, the FEVD itself makes an implicit choice: That is, in specifying the time-varying variables the model follows the generality of the FEM approach, which assumes a variable correlation of unknown form. With respect to the time invariant variables the estimator on the other hand assumes in its basic non-IV form that non of the time-fixed variable is correlated with the individual effects.[46]

If the implicit (and fixed) choice of the FEVD does not reflect the true correlation between the variables and the error term the estimator may perform poor relative to the HT case since it employs inconsistent information for estimation.[47] Recent Monte Carlo simulation results by Alfaro (2006), Plümper & Tröger (2007) and Mitze (2008) however show that even if the FEVD does not meet the underlying true orthogonality conditions of the data set, due to is robust non-IV specification it has a smaller bias and prediction errors than the consistent Hausman-Taylor based alternatives especially for estimating the coeffcicients of both endogenous and exogenous time-fixed variables.

[46] In fact, a modification of the FEVD also allows for the possibility to estimate the second step as IV regression and thus account for endogeneity among time invariant variables and η_{ij}. However, this brings back the classification problem from the Hausman-Taylor specification, which we explicitly aim to avoid by non-IV estimation.

[47] In fact, Hausman-Taylor (1981) label FEVD type estimators 'consistent but inefficient'. For a general discussion of two-step FEM based models in the spirit of the HT approach see e.g. Atkinson & Cornwell (2006).

Table A.1: Empirical literature review on trade FDI linkages

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Kueh et al. (2007)	ASEAN-5	inward FDI; imports and exports	1971 - 2005	Supra-national data building for the ASEAN-5 aggregate (Indonesia, Malaysia, Philippines, Singapore and Thailand)	Error correction time-series model to identify both short and long run causalities between trade and inward FDI	Stable long-run co-integration relationship among FDI, Exports and Imports with 1.) FDI and imports being complements in the long run, while imports tend to substitute FDI in the short run; 2.) Exports are substitutes to FDI in the long run and complementary to each other only in the short run
Pfaffermayr (1996)	Austria	Exports; outward FDI stocks	1981 - 1991	Disaggregated, bilateral data for manufacturing (with 7 sub-sectors)	Dynamic panel data estimation (in 1.differences, see Arellano-Bond, 1991) for trade and FDI equations separately	Positive parameter estimates for the lagged cross-equation variable terms in both the export and outward FDI equation
Brenton, Di Mauro & Lücke (1999)	AUT, FIN, FRA, GER, NED, NOR, SWI, UK, US, JPN, South Korea	Exports; Imports; outward FDI stocks	mid-1990s	Bilateral, aggregate data for OECD countries also sub-aggregates (EU, CEEC1st and CEEC2nd round accession, Russia & Ukraine)	Two-step approach: Using residuals of single equation FDI (gravity) models to augment import and export gravity equations to test for cross-variable linkages	In the case of exports the FDI residual is significant and positive for 7 out of 11 FDI source countries; for imports the FDI residual is significant and positive for 6 out of 11 countries
Ekanayake, Vogel & Veera-macheneni (2003)	Brazil	Exports, outward FDI flows	1960 - 2001	Aggregate time series data	Three equation VAR (in 1.diff.) and addtionally VECM model estimation for FDI, exports and output	Positive causal relationship for export led FDI, but no indication for FDI led export activity
Rothmuller (2003)	Brazil	Exports; Imports; inward FDI stocks and flows	1995 - 2002 for FDI flow data; FDI stocks are artificially constructed based on the initial 1995 value and annual flows	Export and import data for 10 major manufacturing sectors disaggregated by 38 main trading partners; FDI disaggregated by industry and country of origin	Augmented gravity model equations for imports and exports using FDI flows and stocks as additionally explanatory variables	FDI stocks and flows show a positive correlation for the import equation, negative (based on FDI stocks) but insignificant for the export equation; this result is also confirmed for individual regression for manufacturing sub sector (solely exception: imports and FDI flows in the metal products sector)

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Li (2003)	China	Exports; Imports; outward and inward FDI stocks	1989 - 2000	Bilateral aggregate data for 75 countries, additionally aggregated into 6 macro regions (Asia, Africa, Europe, Latin America, North America and Oceania)	Import and export gravity models augmented by contemporaneous outward and inward FDI stocks as additional explanatory variables	Generally complementary linkages between FDI and trade dominate; however, the patterns of relationship between FDI and trade flows highly depend on the stage of similarities between investing and recipient countries (e.g. both in-, outward FDI from/to Europe and Oceania are substitutes to export flows)
Fontagne & Pajot (1997)	France	Exports; outward and inward FDI flows and stocks	1984 - 1995 for FDI flows; 1989 - 1994 for FDI stocks	Bilateral country data for 22 sectors with 39 partner countries (43 in the case of FDI stock estimates)	Gravity equation specification for exports and imports including variables for inward and outward FDI (both flows and stocks in separate specifications)	Outward FDI is complementary to exports and substitutive for imports; foreign FDI is complementary to both export and import activity
Egger & Pfaffermayr (2004)	Germany	Exports; outward FDI stocks	1989-1999	Bilateral data for the manufacturing sector (4 sub-sectors) with 29 partner countries	Two-equation system estimates based on a Hausman-Taylor SUR model closely related to gravity type models (with a prominent role for transportation or plant setup costs)	Exports and outward FDI stocks: Negative correlation between the two variables measured by the error component matrix of the two equations after controlling for common exogenous determinants
Bayoumi & Lipworth (1997)	Japan	Exports; Imports; outward FDI stocks and outflows	1985 - 1995	Bilateral, aggregate data with 20 major trading partners	Augmented trade panel regressions (in 1.diff) using FDI stocks and flows as explanatory variables	Exports and outward FDI flows: positive linkages; exports and outward FDI stocks: insignificant; imports and outward FDI flows: insignificant imports and outward FDI stocks: positive; generally: FDI has only a temporary impact on exports, while outward FDI has a permanent influence on Japanese imports
Bloningen (2001)	Japan	Exports and foreign affiliate production	1978 - 1991 for Japanese automobile parts; 1979 - 1994 for Japanese final consumer products	Bilateral data solely to the USA for 10 automobile parts products and 11 consumer goods	SUR estimation of US import demand for Japanese automobile parts and final consumer products with Japanese sectoral production in the USA as included explanatory variable	Substitutive effects at the product level data: US imports from Japan decline when Japanese foreign investment creates a US manufacturing presence (all 10 equations for automobile parts; as well as 9 out of 11 equations for final consumer goods show a negative regression coefficient)

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Graham (1999)	Japan	Exports; Imports; outward FDI stocks	1993	Bilateral data for 36 individual countries (using different sub aggregates: World, Non East Asia, East Asia)	Two step approach: 1.) Cross section gravity models for im-, exports and FDI stocks; 2.) Residual regression of the Export/Import and FDI equation residuals	Exports and outward FDI stocks: Positive for World, Non East Asia aggregate, Imports and outward FDI stocks: insignificant relationship
Nakamura & Oyama (1998)	Japan	Exports, Imports, outward FDI flows	1979 - 1997	Bilateral data for eight East Asian countries (Taiwan, Korea, China, Malaysia, Singapore, Indonesia, the Philippines and Thailand), also supra-national aggregates are identified based on the similarity of FDI elasticities to macroeconomic vars.	1.) Panel data estimates using a macroeconomic framework to specify import and export equations based on GDP, exchange rates and outward FDI as exogenous regressors 2.) Simultaneous equation models for different country sub-groups (based on aggregated not Panel data); the latter aims to control for a likely simultaneity bias among trade & FDI variables	1.) According to the Panel data model for Japanese imports from the East Asian countries three groups have been identified, which all show significant and positive responses to FDI from Japan; in the case of exports four groups have been identified, except for the Malaysia & China they also show complementaries between Japanese exports and outward FDI, 2.) The SEMs support the positive linkages in the case of imports and exports (except for Indonesia & Philippines)
Pantulu & Poon (2003)	Japan	Exports, Imports; outward FDI stocks and flows	1996 - 1999	Bilateral, aggregate data for 29 partner countries	Gravity model approach (using a spatial affinities gravity model): The model is estimated in two steps, the 1. (auxiliary) step accounts for a simultaneity bias between trade and FDI, in a 2.step FDI stocks and flows are taken as regressors in a trade model for im- and exports	Both outward FDI flows and stocks have a positive impact on export activity; FDI stocks do not have a significant impact on imports; a bilateral analysis shows high country (block) heterogeneity
Tadesse & Ryan (2004)	Japan	Exports; Imports; outward FDI flows	1989 - 1999	Bilateral data for 125 countries; aggregate and industry level data; host countries are grouped according to their geographical and development status	Estimation for FDI equation based on count and value data: With respect to the latter an FDI location model is estimated where lagged export and import flows are added as explanatory variables (panel data setup: Pooled, REM, FGLS)	FDI location equation choice is positively linked to prior export flows; the effect is stronger for developing countries, concerning lagged import flows the estimated relationship to outward FDI flows is negative in the majority of specified models

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Egger (2001)	OECD	Exports; outward FDI stocks	1986 - 1997	Bilateral stocks of outward FDI and exports for all OECD countries	Two-equation system estimates based on a Hausman-Taylor SUR AR(1) model	Exports and outward FDI stocks: Positive correlation between the two variables measured by the error component matrix of the two equations after controlling for common exogenous determinants
Pain & Wakelin (1998)	OECD	Exports; Inward and outward FDI stocks	1971 - 1992 (with two additional sub-samples: 1971 - 1985 and 1986 - 1992	Aggregate time series data for the individual OECD countries	Export demand equation augmented by inward and outward FDI, due to the inclusion of adjustment costs dynamic panel data setup	Outward FDI has a negative impact on trade shares, while inward investment has a generally positive one. For a sample division into two sub-samples: Outward FDI is strongly negative for 1986 - 1992 and insignificant for the prior period
Africano & Magalhaes (2005)	Portugal	Exports; Imports; inward and outward FDI stocks	1998 - 2000	Bilateral aggregate data for OECD countries plus Brazil (total 28); additionally disaggregated data for the manufacturing sector	Gravity equation specification for exports and imports including variables for inward and outward FDI stocks	Inward FDI stocks as complements to both exports and imports; the relationship between outward FDI and trade variables is estimated insignificant; results hold for aggregate and industy level data
Ahn, Lee, Lee & Woo (2005)	South Korea	Export; outward FDI flows	1991 - 2003	Industry level (3-digit) data for manufacturing sector (total 71 industries); grouped into aggregates: low-tech, medium-low and medium-high, high-tech industries	1.) Estimation of a simple export growth model with lagged FDI growth and export growth rates as explanatory variables, 2.) instrumental variable approach to account for simultaneity among exports and FDI (using instruments for both vertical and horizontal FDI motives)	Simple export growth estimates find complementary effects of FDI on exports for high-tech firms (vertical integration hypothesis), however using IV-regression the trade-FDI relationship turns out to be strongly substitutive (for the total industry aggregate and (medium) low-tech group, insignificant for (medium) high-tech industries)
Graham & Liu (1998)	South Korea	Exports; Imports; outward FDI stock	1993	Bilateral trade and FDI data for the manufacturing sector	Two step approach: 1.) Cross section gravity models for im-, exports and FDI stocks; 2.) Residual regression of the Export/Import and FDI equation residuals	Exports and outward FDI stocks: Positive correlation of the residuals, imports and outward FDI stocks: insignificant estimation results

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Lee (2002)	South Korea	Exports, Imports, outward FDI flows	1991 - 1993, 1997 - 1999	Bilateral trade and FDI data for 102 trading partners	Augment import and export gravity models which use 1.) lagged FDI flows as regressor, 2.) residuals from single equation FDI (gravity) models as regressors	Estimated coefficients of FDI flows on exports are positive and statistically significant for most years of the sample period; the effect of FDI on imports is statistically insignificant for the sample period, a reversed test of trade effects on FDI activity turns also out to be insignificant
Zarotiadis & Mylonidis (2005)	UK	Exports; Imports; inward FDI stocks	1995 - 2003	Bilateral, aggregate and industy level FDI data for USA, Germany, France & Japan	Augmented panel import and export regression (in 1.diff) using FDI stock aggregates as explanatory variables	Exports and inward FDI: Positive for most country-industry pairs, Imports and inward FDI: Mixed results, mostly positive at the aggregate level, negative for manufacturing FDI out of France and Japan to the UK
Brainard (1997)	USA	Exports; Imports; FDI sales by home and host country multinational enterprises	1989	Sectorally disaggregated data on Exports and outward FDI of US MNEs, as well as imports and inward FDI for 27 countries	Cross section gravity equations for export and import shares (of i and country j compared to overall ex- and imports) as well as outward and inward affiliate sales share (for sector n and country m relative to overall MNEs sales); additionally estimates in absolute values	MNEs are most likely to serve target markets via foreign affiliate sales - as opposed to exports - if the industry is characterized by high transportation costs, minimal plant scale economies, high tariffs and openness to foreign investment; overall complementaries
Clausing (2000)	USA	Exports; Imports; outward and inward FDI stocks	1977 - 1994	Two datasets: 1.) Bilateral data on Exports and outward FDI of US multinationals in 29 host countries; 2.) Imports and FDI on 29 partner countries	Gravity equation specification of trade including variables reflecting multinational activities (in particular net local sales defined as FDI corrected for intra firm trade)	Complementary relationship of US exports and outward FDI stocks; for US imports and inward FDI stocks no clear results
Egger & Pfaffermayr (2004)	USA	Exports; outward FDI stocks	1989-1999	Bilateral data for the manufacturing sector (7 sub-sectors) with 69 partner countries	Two-equation system estimates based on a Hausman-Taylor SUR model closely related to gravity type models (with a prominent role for transportation or plant setup costs)	Exports and outward FDI stocks: positive correlation between the two variables measured by the error component matrix of the two equations after controlling for common exogenous determinants

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Ekanayake, Vogel & Veera-macheneni (2003)	USA	Exports, outward FDI flows	1960 - 2001	Aggregate time series data	Three equation VAR (in first difference) and additionally VECM model estimation for FDI, exports and output (GDP)	Positive causal relationship for both export led FDI and for FDI led export activity
Fontagne & Pajot (1997)	USA	Exports; outward and inward FDI flows and stocks	1980 - 1995	Bilateral country data for 12 sectors with 45 partner countries	Gravity equation specification for exports and imports including variables for inward and outward FDI (both flows and stocks in separate specifications)	US FDI abroad is characterised by a reallocation strategy, leading to increasing import activity; in contrast foreign investors to the US are primary motivated by an entry in the domestic market, thus they substitute sales that were previously exported to the USA
Goldberg & Klein (1999)	USA	Outward FDI flows; net exports	1972 - 1994	Bilateral, sectorally disaggregated data for Latin America	Augmented export regressions (in 1.diff) using FDI flows as explanatory variables for each country using (time x industry) panel data	Negative sectoral linkages for Mexico and Venezuela (except Banking, Finance sector in the case of Venezuela); mixed results for Brazilian and Columbian sectors; positive sectoral correlation for net trade in the targeted FDI sector for Argentina
Graham (1999)	USA	Exports; Imports; outward FDI stocks	1983; 1988; 1991	Bilateral data for 40 individual countries (for World, Europe, Western Hemisphere, East Asia sample)	Two step approach: 1.) Cross section gravity models for im-, exports and FDI stocks; 2.) Residual regression of the Export/Import and FDI equation residuals	Exports and outward FDI stocks: positive, except sub aggregate Western Hemisphere; Imports and outward FDI stocks: positive, non significant for Western Hemisphere and East Asia
Nakamura & Oyama (1998)	USA	Exports, Imports, outward FDI flows	1982 - 1997	Bilateral data for eight East Asian countries (Taiwan, Korea, China, Malaysia, Singapore, Indonesia, the Philippines and Thailand); supra national aggregates based on the similarity of FDI elasticities to macroeconomic vars.	Panel data estimates using a macroeconomic framework to specify import and export equations based on GDP, exchange rates and outward FDI as exogenous regressors	According to the Panel data model for imports two country groups show no significant response of Japanese imports to outward FDI from Japan; in the case of US exports to the East Asian countries again two groups have been identified, which show positive but small responses to outward FDI from the US

Author	Country	Variables	Time Period	Type of data	Estimation technique	Type of trade-FDI linkage
Pantulu & Poon (2003)	USA	Exports, Imports; outward FDI stocks	1996 - 1999	Bilateral aggregate data for the USA and 32 partner countries	Gravity model approach (using a spatial affinities gravity model): The model is estimated in two steps, the 1. (auxiliary) step accounts for a simultaneity bias between trade and FDI, in a 2.step FDI stocks and flows are taken as regressors in a trade model for im- and exports	FDI stocks have a positive and significant influence on both US exports and imports, these results hold even after the model is controlled for any simultaneity bias; a bilateral analysis shows high country (bloc) heterogeneity
Swenson (2004)	USA	Imports; inward FDI stocks	1974 - 1994	Bilateral, sectorally disaggregated data (product, industry and overall level) for the manufacturing sector	Augmented import regressions using FDI flows as explanatory variables in a pooled (as well as bilateral) estimation setup	Mixed results: Complementaries based on aggregated manufacturing data, substitutive linkages at the country level using product and industry level FDI data
Türkcan (2008)	USA	Exports and outward FDI stocks	1989 - 2003	Bilateral, outward FDI stocks and finished/intermediate goods exports (based on five-digit SITC) between the US and 25 OECD countries	Single equation Gravity model specification with (total manufactured, final and intermediate) exports as dependent variable, outward FDI stocks as r.h.s. regressor, FEM and REM panel data estimator	Regression results demonstrate a positive relationship between US intermediate exports and outward FDI (vertical FDI motive); in contrast the results find weak evidence of substitution effects between US finished goods exports and outward FDI stocks (horizontal FDI motive)
Cechella et al. (2008)	World sample (65 countries)	trade volume; in- and outward FDI (based on performance indices)	2005	Bilateral aggregate (index) data	Cross-country trade model based on the standard gravity-type setup augmented by export country dummies taking into account that trade is more dependent on the effort of the exporter than on the request of the importer	Indicator for FDI was found to have a strongly significant negative effect on trade flows supporting the view of substitutive linkages among trade and FDI, the authors conclude that world FDI is merely driven by horizontal motives (when disaggregated outward FDI turned out to be insignificant in the regression)

Table A.2: Data description and source

Variable	Description	Source
EX_{ijt}	Export volume, nominal values, in Mio.	Statistisches Bundesamt (German statistical office)
IM_{ijt}	Import volume, nominal values, in Mio.	Statistisches Bundesamt
$FDIout_{ijt}$	Outward FDI stock, nominal values, in Mio.	Deutsche Bundesbank
$FDIin_{ijt}$	Inward FDI stock, nominal values, in Mio.	Deutsche Bundesbank
GDP_{it}	Gross Domestic Product, nominal values, in Mio.	VGR der Länder (Statistical office of the German states)
GDP_{jt}	Gross Domestic Product, nominal values, in Mio.	EUROSTAT
POP_{it}	Population, in 1000	VGR der Länder
POP_{jt}	Population, in 1000	Groningen Growth & Development center (GGDC)
SIM_{ijt}	$SIM = log\left(1 - \left(\frac{GDP_{it}}{GDP_{it}+GDP_{jt}}\right)^2 - \left(\frac{GDP_{jt}}{GDP_{it}+GDP_{jt}}\right)^2\right)$	see above
RLF_{ijt}	$RLF = log\left\lvert\left(\frac{GDP_{it}}{POP_{it}}\right) - \left(\frac{GDP_{jt}}{POP_{jt}}\right)\right\rvert$	see above
EMP_{it}	Employment, in 1000	VGR der Länder
EMP_{jt}	Employment, in 1000	AMECO database of the European Commission
$PROD_{it}$	$Prod_{it} = \left(\frac{GDP_{it}}{EMP_{it}}\right)$	see above
$PROD_{jt}$	$Prod_{jt} = \left(\frac{GDP_{jt}}{EMP_{jt}}\right)$	see above
K_{it}	Capital stock, nominal, in Mio.	VGR der Länder
$KBLC_{it}$	$KBLC_{it} = \left(\frac{K_{it}}{POP_{it}}\right)$	see above
$FDIopen_{jt}$	$FDIopen_{jt} = \left(\frac{Total\ inward_{FDI_{jt}}}{GDP_{jt}}\right)$	FDI: UNCTAD, GDP: see above
KF_{jt}	Capital stock derived from GFCF via perpetual inventory method, nominal, in Mio.	GFCF data from Eurostat
$WAGE_{it}$	Wage compensation per employee, nominal, in 1000	VGR der Länder
$WAGE_{jt}$	Wage compensation per employee, nominal, in 1000	AMECO database of the EU Commission
$DIST_{ij}$	Distance between state capital for Germany and national capital for the EU27 countries, in km	Calculation based on coordinates, obtained from *www.koordinaten.de*
EMU	(0,1)-Dummy variable for EMU members since 1999	
$EAST$	(0,1)-Dummy variable for the East German states	
$CEEC$	(0,1)-Dummy variable for the Central and Eastern European countries	
$BORDER$	(0,1)-Dummy variable for country pairs with a common border	
$t_{1993} - t_{2005}$	Time effects for the years 1993-2005	

Table A.3: Single equation gravity model for export equation

Dep.: $Log(EX)$	**POLS**	**REM**	**FEM**	**FEVD**$^{\#}$	**HT**$^{\$}$
$Log(GDP_i)$	0,63*** (0,187)	-0,17 (0,255)	0,92** (0,397)	0,92** (0,397)	0,76** (0,400)
$Log(GDP_j)$	0,70*** (0,041)	0,22*** (0,049)	0,13** (0,061)	0,13** (0,061)	0,05 (0,055)
$Log(POP_i)$	0,50*** (0,183)	1,25*** (0,248)	-1,94*** (0,581)	-1,94*** (0,581)	-0,78** (0,396)
$Log(POP_j)$	0,15*** (0,039)	0,56*** (0,052)	2,17*** (0,442)	2,17*** (0,442)	0,75*** (0,081)
$Log(PROD_i)$	0,50 (0,334)	2,89*** (0,317)	1,81*** (0,407)	1,81*** (0,407)	2,08*** (0,413)
$Log(DIST_{ij})$	-0,81*** (0,026)	-1,06*** (0,057)	(dropped)	-0,79*** (0,082)	-1,96*** (0,181)
SIM	-0,01 (0,016)	-0,17*** (0,317)	-0,33*** (0,062)	-0,33*** (0,062)	-0,37*** (0,060)
RLF	0,01 (0,014)	0,02** (0,008)	0,01 (0,008)	0,01 (0,008)	0,01 (0,008)
EMU	0,41*** (0,036)	0,23*** (0,025)	0,16*** (0,026)	0,16*** (0,026)	0,18*** (0,025)
$EAST$	-0,80*** (0,049)	-0,41*** (0,085)	(dropped)	-1,17*** (0,072)	-0,63*** (0,179)
$BORDER$	0,26*** (0,055)	0,26* (0,155)	(dropped)	0,76*** (0,063)	-0,18 (0,320)
$CEEC$	0,61*** (0,080)	-0,39*** (0,109)	(dropped)	0,58*** (0,059)	-0,71*** (0,147)
Time effects (Wald F-Test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of obs.	2665	2665	2665	2665	2665
No. of groups		353	353	353	353
BP LM-Test (POLS vs. REM)		6452,1 (0,00)			
F-Test (POLS vs. FEM)			28,3 (0,00)		
***m*-Statistic** (REM vs. FEM)			166,7 (0,00)		
Weak Ident. ($F \geq 10$) Rule					37,8 passed
Sargan overid. (P-value)					5,49 (3) (0,13)
C-Stat. $Dist_{ij}$ (P-value)					26,3 (0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. # = D.f. adjusted FEVD standard errors. $ with: $X1 = [GDP_{jt}, POP_{jt}, PROD_{it}, EMU_{ijt}]$, $Z2 = [DIST_{ij}]$.

Table A.4: Single equation gravity model for outward FDI stocks

Dep. Var: Log(FDIout)	POLS	REM	FEM	FEVD$^{\#}$	HT$^{\$}$
$Log(GDP_i)$	1,97*** (0,552)	5,88*** (0,848)	4,57*** (1,363)	4,57*** (1,363)	5,72*** (0,796)
$Log(GDP_j)$	-1,02*** (0,289)	-0,94** (0,411)	-0,70 (0,596)	-0,70 (0,596)	1,34*** (0,439)
$Log(POP_i)$	-0,29 (0,540)	-4,01*** (0,829)	-1,43 (1,995)	-1,43 (1,995)	-4,30*** (0,771)
$Log(POP_j)$	1,92*** (0,232)	2,29*** (0,325)	0,58 (1,554)	0,58 (1,554)	1,40*** (0,449)
$Log(PROD_i)$	2,81*** (0,984)	-5,31*** (1,065)	-4,43*** (1,396)	-4,43*** (1,396)	-5,09*** (1,148)
$Log(DIST_{ij})$	-0,79*** (0,081)	-1,05*** (0,209)	(dropped)	-1,75*** (0,371)	-2,64*** (0,378)
$Log(WAGE_j)$	1,40*** (0,213)	1,41*** (0,334)	1,12** (0,488)	1,12** (0,488)	-0,56* (0,324)
$Log(FDIopen_j)$	0,62*** (0,062)	0,29*** (0,093)	0,04 (0,113)	0,04 (0,113)	1,39*** (0,198)
$Log(KF_j)$	0,39** (0,194)	-0,07 (0,304)	-0,95** (0,456)	-0,95** (0,456)	-1,12*** (0,347)
SIM	0,55*** (0,051)	1,03*** (0,112)	1,80*** (0,222)	1,80*** (0,222)	1,61*** (0,219)
RLF	-0,04 (0,037)	0,01 (0,027)	0,02 (0,027)	0,02 (0,027)	0,01 (0,028)
EMU	-0,03 (0,121)	-0,64*** (0,094)	-0,77*** (0,108)	-0,77*** (0,108)	-0,57*** (0,090)
$EAST$	-2,77*** (0,146)	-3,44*** (0,283)	(dropped)	-3,78*** (0,328)	-3,38*** (0,287)
$BORDER$	0,58*** (0,163)	0,74 (0,511)	(dropped)	1,07*** (0,304)	-0,68 (0,514)
$CEEC$	0,14 (0,238)	-1,04** (0,281)	(dropped)	-5,69*** (0,401)	-2,32*** (0,419)
Time effects (Wald F-Test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of obs.	2665	2665	2665	2665	2665
No. of groups		353	353	353	353
BP LM-Test (POLS vs. REM)		2483,9 (0,00)			
F-Test (POLS vs. FEM)			19,18 (0,00)		
***m*-Statistic** (REM vs. FEM)			98,04 (0,00)		
Weak Ident. ($F \geq 10$) Rule					41,42 passed
Sargan Overid. (P-value)					10,06 (4) (0,04)
C-Stat. $Dist_{ij}$ (P-value)					11,88 (0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. # = D.f. adjusted FEVD standard errors. $ with: $X1 = [POP_{it}, POP_{jt}, PROD_{it}, WAGE_{jt}, KF_{jt}]$, $Z2 = [DIST_{ij}]$.

Table A.5: Single equation gravity model for import equation

Dep.: $Log(IM)$	**POLS**	**REM**	**FEM**	**FEVD**$^{\#}$	**HT**$^{\$}$
$Log(GDP_i)$	1,68*** (0,094)	1,70*** (0,158)	1,55*** (0,232)	1,55*** (0,232)	1,71*** (0,207)
$Log(GDP_j)$	1,25*** (0,168)	1,52*** (0,184)	1,76*** (0,197)	1,76*** (0,197)	1,70*** (0,206)
$Log(POP_i)$	-0,58*** (0,093)	-0,62*** (0,157)	-0,79* (0,491)	-0,79* (0,491)	-0,72*** (0,186)
$Log(POP_j)$	-0,38** (0,162)	-0,66*** (0,181)	2,42*** (0,594)	2,42*** (0,594)	-0,95*** (0,205)
$Log(PROD_j)$	-0,31* (0,169)	-1,30*** (0,195)	-1,60*** (0,215)	-1,60*** (0,215)	-1,68*** (0,215)
$Log(DIST_{ij})$	-1,01*** (0,036)	-1,34*** (0,079)	(dropped)	-1,15*** (0,105)	-2,08*** (0,156)
SIM	0,06*** (0,022)	-0,12*** (0,044)	-0,26*** (0,079)	-0,26*** (0,079)	-0,34*** (0,072)
RLF	0,09*** (0,016)	0,05*** (0,010)	0,04*** (0,010)	0,04*** (0,010)	0,05*** (0,010)
EMU	0,38*** (0,048)	0,01 (0,035)	-0,12*** (0,038)	-0,12*** (0,038)	-0,02 (0,035)
$EAST$	-0,61*** (0,058)	-0,55*** (0,116)	(dropped)	-0,29*** (0,091)	-0,68*** (0,159)
$BORDER$	0,41*** (0,073)	0,37* (0,218)	(dropped)	-0,99*** (0,081)	-0,38* (0,235)
$CEEC$	1,06*** (0,108)	-0,30** (0,147)	(dropped)	2,51*** (0,075)	-0,63*** (0,120)
Time effects (Wald F-Test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of obs.	2665	2665	2665	2665	2665
No. of groups		353	353	353	353
BP LM-Test (POLS vs. REM)		5711,1 (0,00)			
F-Test (POLS vs. FEM)			33,54 (0,00)		
***m*-Statistic** (REM vs. FEM)			148,0 (0,00)		
Weak Ident. ($F \geq 10$) Rule					62,05 passed
Sargan Overid. (P-value)					5,91 (3) (0,12)
C-Stat. $Dist_{ij}$ (P-value)					11,94 (0,00)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. # = D.f. adjusted FEVD standard errors. $ with: $X1 = [GDP_{it}, POP_{it}, POP_{jt}, PROD_{jt}]$, $Z2 = [DIST_{ij}]$.

Table A.6: Single equation gravity model for inward FDI stocks

Dep. Var: Log(FDIin)	POLS	REM	FEM	FEVD[#]	HT[$]
$Log(GDP_i)$	4,03*** (0,264)	2,64*** (0,455)	1,49** (0,618)	1,49** (0,618)	3,80*** (0,517)
$Log(GDP_j)$	4,02*** (0,411)	4,82*** (0,435)	4,96*** (0,462)	4,96*** (0,462)	3,70*** (0,958)
$Log(POP_i)$	-1,38*** (0,367)	1,39*** (0,393)	7,01*** (1,418)	7,01*** (1,418)	0,95** (0,454)
$Log(POP_j)$	-4,48*** (0,573)	-6,86*** (0,545)	-0,65 (1,451)	-0,65 (1,451)	-5,56*** (0,953)
$Log(PROD_j)$	-2,67*** (0,412)	-5,02*** (0,462)	-5,29*** (0,504)	-5,29*** (0,504)	-3,54*** (1,086)
$Log(DIST_{ij})$	-1,89*** (0,086)	-2,78*** (0,201)	(dropped)	-3,02*** (0,255)	-2,69*** (0,301)
$Log(KBLC_j)$	-1,44*** (0,422	-2,89*** (0,334)	-1,48*** (0,465)	-1,48*** (0,465)	-2,78*** (0,345)
SIM	0,11** (0,054)	-0,05 (0,109)	0,03 (0,185)	0,03 (0,185)	-0,40** (0,183)
RLF	-0,32*** (0,041)	-0,07*** (0,024)	-0,06*** (0,024)	-0,06*** (0,024)	-0,05* (0,026)
EMU	-0,37*** (0,119)	0,42*** (0,084)	0,34*** (0,089)	0,34*** (0,089)	0,59*** (0,122)
$EAST$	-0,22 (0,210)	-1,47*** (0,296)	(dropped)	2,58*** (0,224)	2,72** (1,417)
$BORDER$	0,02 (0,182)	-0,49 (0,558)	(dropped)	-5,86*** (0,199)	-1,57*** (0,569)
$CEEC$	-1,97*** (0,264)	-3,86*** (0,361)	(dropped)	0,31* (0,181)	-4,33*** (0,301)
Time effects (Wald F-Test)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)	Yes (0,00)
No. of obs.	2665	2665	2665	2665	2665
No. of groups		353	353	353	353
BP LM-Test (POLS vs. REM)		4772,5 (0,00)			
F-Test (POLS vs. FEM)			36,72 (0,00)		
***m*-Statistic** (REM vs. FEM)			120,6 (0,00)		
Weak Ident. ($F \geq 10$) Rule					6,88 weak
Sargan overid. (P-value)					10,8 (4) (0,03)
C-Stat. $Dist_{ij}$ (P-value)					2,36 (0,12)

Note: ***, **, * = denote significance levels at the 1%, 5% and 10% level respectively. # = D.f. adjusted FEVD standard errors. $ with: $X1 = [GDP_{it}, GDP_{jt}, POP_{jt}, KBLC_{it}, RLF_{ijt}]$, $Z2 = [DIST_{ij}]$.