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Trade-FDI Linkages in a System of Gravity Equations for German Regional Data

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Abstract
We analyse the nature of German trade-FDI linkages within the EU27 based on a simultaneous equation gravity approach for imports, exports, in- and outward FDI stocks. We adopt both a Hausman-Taylor (1981) IV approach (3SLS-GMM) and rival non-IV estimation (the system extension to the Fixed Effects Vector Decomposition model recently proposed by Plümper & Tröger, 2007). Turning to the results, both estimators give empirical support for our chosen gravity setup as an appropriate framework in explaining German trade and FDI activity. Looking carefully at cross-variable linkages we basically find substitutive links between trade flows and outward FDI in line with earlier empirical evidence for Germany. Building upon German state level data we are also able to analyse the sensitivity of the results for regional sub-samples. The latter disaggregation hints at structural differences among the trade and FDI activity of the two West and East German 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 West German–EU27 trade & FDI as an example, the identified pairwise linkages closely follow the theoretical predictions of New Trade Theory models as in Baldwin & Ottaviano (2001): That is, when trade is merely of intra-industry type with non-zero trade costs, we observe export replacement effects of FDI. However, at the same time outward FDI stimulates trade via reverse good imports. For the West German–EU15 sub-sample we even reveal complementaries among export and outward FDI activity. This strongly advocates to care for the regional dimension in analysing cross-variable linkages of trade and FDI.

JEL Classification: C33, F14, F21

Keywords: Trade, FDI, panel data, simultaneous equations

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1 Introduction

In this paper we aim to explore the German trade-FDI nexus within the EU27 as being complementary or substitutive in nature.[1] Whereas predictions from standard trade models of the Heckscher-Ohlin type typically handle both variables as substitutes, recent theoretical contributions in the field of 'New Trade Theory' show a more diverse picture, when carefully accounting for the growing complexity of multinational enterprises (MNEs) investment strategies following both horizontal (market seeking) and vertical (cost oriented) investment motives. According to these latter models both substitutive and complementary linkages could potentially arise, crucially depending on the chosen model assumptions. Adding on these ambiguous findings of the theoretical literature in solving the trade-FDI puzzle, there is also an steadily increasing stock of empirical contributions making use of a broad variety of statistical tools in order to gain insights into the underlying trade-FDI relationships for individual countries or country groups.

The huge research effort spent on solving the trade-FDI puzzle reflects to some extent the great interest on this subject in the policy debate: As Pantulu & Poon (2003) point out, trade substitutability and replacement effects are often a 'hot topic' in the globalization debate of industrialized countries, where it is critically argued that outward FDI typically lead to deindustrialisation and displacement effects of employment, especially in export-based industries. Thus, for the German economy with a strong export orientation this analysis may be seen a very sensitive but nevertheless important issue. Only few empirical studies have dealt with the German trade-FDI interrelations so far, where the results generally show a substitutive relationship between exports and outward FDI at the national level (see Jungmittag, 1995, for selected European countries and the USA between 1973-89 as well as Egger & Pfaffermayr, 2004, for a world sample between 1989-99). Throughout the paper we will basically take up the empirical path of the latter authors and enrich the analysis by incorporating also import volumes and inward FDI stocks next to further methodological innovations.

To shed some more light on the trade-FDI puzzle, we analyse the intra-EU27 trade and FDI patterns for the 16 German federal states (NUTS1-level) based on a panel data set of bilateral region-to-nation trade volumes and FDI stocks covering a sample period from 1993 to 2005.[2] We apply gravity kind models in order to identify the driving forces

[1] An extended version of this paper with a detailed discussion of (empirical) contributions to the analysis of trade-FDI linkages, the theoretical foundations of the gravity model and additional estimation results can be downloaded as MPRA Paper No. 12245.

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

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 both Instrumental Variable (IV) and non-IV simultaneous equation 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. Moreover, with an emphasis on a regional modelling perspective we also put a special focus on analysing the sensitivity of the results with respect to the two West and 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 transformation and cohesion of the East German states.

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. Section 3 presents the database and some stylised facts for German trade and FDI within the EU27. Section 4 discusses the econometric specification and empirical results of the simultaneous equation modelling approach for the system of gravity models of trade and FDI and 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 5 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.[3] As outlined above, from the perspective of the theoretical literature both type of interaction channels favouring a complementary or substitutive relations among the variables can be found. 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 compe-

[3] Markusen (1995), Jungmittag (1995), Zarotiadis & Mylonidis (2005) and Blanchard et al. (2008) among other provide detailed surveys of recent theoretical contributions.

tition. A prominent approach of the latter type is the so-called proximity-concentration trade-off explored by Brainard (1993, 1997). Here, under the assumption non-zero trade costs, 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 versus concentrating production in one location, which is associated with the exploitation of economies of scale.

On the contrary, a bulk of recent contributions derive complementaries between trade and FDI: Starting point is the General Equilibrium model of Helpman (1984), which models 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. Starting from a critical reflection of the 'proximity-concentration trade-off' literature, Baldwin and Ottaviano (2001) show that complementary and substitutive elements in trade-FDI activity may coexist: 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 empirical analysis of German trade/FDI activity within the EU27 the model may 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 theoretical literature there are also various empirical approaches aiming to pin down the trade-FDI-nexus for individual countries or country groups: Though we may conclude from this field of research that 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 in terms of a country's stage of internationalization activity.

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 macro 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).[4] 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 most papers focus on the link between exports and outward FDI, though recent findings indicate that the full set of cross-variable linkages may be of importance (as e.g. shown in the model by Baldwin & Ottaviano, 2001). Without any claim on completeness we discuss some selected results of the empirical literature: 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

[4]According to Pantulu & Poon (2003) as similar set-up would be to run an IV regression of trade on FDI in the form of a Pyndick-Rubinfeld test for simultaneity. For this setup Pantulu & Poon (2003) recommend to use the variables from the gravity model as proper instruments.

& 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 (including 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 (West) German data, Jungmittag (1995) and Egger & Pfaffermayr (2004) identify substitutive relationships - however only focusing on exports and outward FDI stock.

3 Data and Stylized Facts of German Trade-FDI activity

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).[5] 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.[6] Detailed variable descriptions and data sources for the variables included in the analysis are given in table 1.

<< insert Table 1 about here >>

[5] 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.

[6] 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 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).

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 the empirical application now predominantly has switched to panel data estimation (exceptions with an explicit account of time series properties 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 - 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 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 are discussed in Zwinkels & Beugelsdijk (2008).

<< insert Table 2 about here >>

Before we turn to the specification of the empirical model, 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 worldwide 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.[7] Taking a closer look at the bilateral trade pattern with Germany's major trading partners, for import flows 6 out of the 10 major partners come from the EU27 and for exports these are even 8 out of 10 (in 2005). 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 high degree of internationalisation of German firms can also be observed with respect to FDI data: In the year 2005 the total outward FDI stocks of German firms are only outranked by its US and UK competitors. Again correcting for economic size, we see that Germany with an outward FDI stock ratio of 34,6 % of national GDP outranks the US (16,4 %) though the gap to the UK (56,25 %) remains. Compared to exports the EU27-wide outward FDI share (relative to the total outward FDI stock) is with 51,9 % for the average period 1993-2005 somewhat lower, but still amounts for a significant part.[8] 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).

[7]Only the OR of China was with 69,7 % in 2004 even larger. Moreover, the German dominance also holds in an intra-European comparison (e.g. looking at the OR for Italy = 37,2 %, UK = 34,8 % and France = 40,8 %).

[8]The remainder part of Germany's outward FDI stock is mainly directed to the US (29,6 % in 2005).

Looking at German regional trade and FDI intensities (defined as regional trade/FDI per regional GDP), table 3 reports regional differences 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).[9] Examining the differences between the two West and East German macro regions, table 3 shows that the East German states trade half as much as the German average (0,52 both for total as well as intra-EU trade for the average 2000-2005). And the East-West gap is slightly wider for import intensities. Both indicators 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).[10]

With respect to the FDI intensities table 3 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 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). Moreover, while for the export activity a gradual catching-up of the Eastern relative to the Western states could be observed, for FDI stocks the gap remains stable or even widens recently. For inward FDI the West-East 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 East German firms to actively invest abroad. The strong (macro) regional

[9] 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, which are typically tested in a gravity model context.

[10] Again, for the Saarland the import intensity with respect to EU27 countries is again much higher (1,97).

differences are also shown graphically in figure 1. 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 German export and FDI performance.

<< insert Table 3 and Figure 1 about here >>

4 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. 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 (see e.g. Sen & Smith, 1995, Matyas, 1997, Egger, 2000, or Feenstra, 2004). Using a log linear form and variable selection based on both theoretical and statistical concerns our resulting estimation system can be summarized as follows:

$$\begin{aligned} log(EX_{ijt}) &= \alpha_0 + \alpha_1 + \alpha_2 log(GPD_{jt}) + \alpha_3 log(POP_{it}) \\ &+\alpha_4 log(POP_{jt}) + \alpha_5 log(PROD_{it}) + \alpha_6 log(DIST_{ij}) \\ &+\alpha_7 SIM + \alpha_8 RLF + \alpha_9 EMU \\ &+\alpha_{10} EAST + \alpha_{11} BORDER + \alpha_{12} CEEC + \sum_{r=1993}^{2005} \alpha_r t_r, \end{aligned} \quad (1)$$

$$\begin{aligned} log(FDIout_{ijt}) &= \beta_0 + \beta_1 log(GDP_{it}) + \beta_2 log(GPD_{jt}) + \beta_3 log(POP_{it}) \\ &+\beta_4 log(POP_{jt}) + \beta_5 log(PROD_{it}) + \beta_6 log(DIST_{ij}) \\ &+\beta_7 log(WAGE_{jt}) + \beta_8 log(FDIopen_{jt}) + \beta_9 log(KF_{jt}) \\ &+\beta_{10} SIM + \beta_{11} RLF + \beta_{12} EMU \\ &+\beta_{13} EAST + \beta_{14} BORDER + \beta_{15} CEEC + \sum_{r=1993}^{2005} \beta_r t_r, \end{aligned} \quad (2)$$

$$
\begin{aligned}
log(IM_{ijt}) \;=\;& \gamma_0 + \gamma_1 log(GDP_{it}) + \gamma_2 log(GDP_{jt}) + \gamma_3 log(POP_{it}) \\
& + \gamma_4 log(POP_{jt}) + \gamma_5 log(PROD_{jt}) + \gamma_6 log(DIST_{ij}) \\
& + \gamma_7 SIM + \gamma_8 RLF + \gamma_9 EMU \\
& + \gamma_{10} EAST + \gamma_{11} BORDER + \gamma_{12} CEEC + \sum_{r=1993}^{2005} \gamma_r t_r,
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
log(FDIin_{ijt}) \;=\;& \delta_0 + \delta_1 log(GDP_{it}) + \delta_2 log(GPD_{jt}) + \delta_3 log(POP_{it}) \\
& + \delta_4 log(POP_{jt}) + \delta_5 log(PROD_{jt}) + \delta_6 log(DIST_{ij}) \\
& + \delta_7 log(KBLC_{it}) + \delta_8 SIM + \delta_9 RLF \\
& + \delta_{10} EMU + \delta_{11} EAST + \delta_{12} BORDER + \delta_{13} CEEC + \sum_{r=1993}^{2005} \delta_r t_r.
\end{aligned} \tag{4}
$$

The dependent variable EX_{ijt} in eq.(1) represents country i's exports to country j for time period t with an analogous notation for outward FDI ($FDIout_{ijt}$) in eq.(2). The sub-indices for imports (IM_{ijt}) and inward FDI ($FDIin_{ijt}$) in eq.(3) and eq.(4) respectively denote trade/FDI activity to i from j in period t.[11] A discussion of the theoretically motivated coefficient signs of the variables in the trade-FDI system is given in table 4. 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.

<< insert Table 4 about here >>

When estimating the system in eq.(1) to eq.(4) we carefully account for the trade-off between the likely increase in estimation efficiency based on a full information system approach, 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 system by full information estimation, which in turn may translate into increasingly biased results if the estimation error of one equation is pumped through the whole system.

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

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 type models recently.

The Hausman-Taylor (1981) model may be seen 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 still avoid the strong 'all or nothing' assumptions of the FEM and REM in terms of residual correlation of the right hand side regressors respectively. The Hausman-Taylor model therefore splits both the vectors of time-varying and time-fixed variables into two subvectors classifying the variables as either being correlated or uncorrelated with the unobservable individual effects. This classification scheme is then used to derive consistent instruments for model estimation. We use the HT setup for estimating a 3SLS-GMM estimator, which has the advantage over standard 3SLS estimation that it allows to use different instruments in subsequent equations of the system, while standard 3SLS 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.[12] For convenience and in line with the mainstream literature on the Hausman-Taylor model we assume that the variance-covariance matrix of the error terms takes the random effect form.[13]

As 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 two-step approach estimates the coefficient vector of the time-varying variables by FEM in a

[12]Detailed results are reported in Mitze et al. (2008) or can be obtained from the authors upon request.

[13]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.

first step and then applies pooled OLS (POLS) in a second step to obtain the coefficient vector for these variables, 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. Since this second step includes a 'generated regressand' we have to adjust standard errors here. One 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. 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 for gravity type models (see e.g. Belke & Spies, 2008, Caporale et al., 2008, Etzo, 2007, and Krogstrup & Wälti, 2008, among others). 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).

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 system 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 seemingly unrelated regression (SUR) framework adjusting for the system's 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). We apply 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). Additonal details on the specification of both estimators including the bootstrapping procedure for the FEVD-SUR are given in the appendix.

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.(1) to eq.(4) 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). That is, elements beside the main diagonal in variance-covariance matrix of the (composed) error term can be used as estimates for the underlying state-country pair trade and FDI linkages. 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 setup suggested by Egger & Pfaffermayr (2004) may thus 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). We use Breusch-Pagan (1980) type tests corrected for unbalanced panel data sets according to Song & Jung (2001) and Baltagi & Song (2006) to check for the significance of the cross-equation residual correlation.[14]

Turning to the estimation output, table 5 plots the results for the Hausman-Taylor 3SLS-GMM estimator and table 6 reports the FEVD-SUR findings. We first give a very 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 individual equations' variable coefficients, 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 distinct role in line with the theoretical gravity model assumptions. Only for the export equation the results show a surprisingly low explanatory power of income variables: That is, they out to be of expected coefficient sign but only (weakly) significant in the FEVD-SUR approach, while they are tested insignificant in the HT-3SLS-GMM. On the contrary, for export activity home productivity (defined as GDP per total employment) is significanlty positive for both the HT-3SLS-GMM and the FEVD-SUR. 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 micro based literature (see e.g. Helpman et al., 2003, Arnold & Hussinger, 2006.).

[14]Further Details on the specification of the test statistic are given in the appendix.

Geographical distance as proxy for transportation costs shows the theoretically expected negative sign in the export equation. Thereby, for the HT model the coefficient clearly 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 particularly 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.[15] Also the remainder equations of our trade-FDI system assign a crucial role to distance, while the effect is found to be on average 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' EU27 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 result 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. Ekholm, 1998).[16]

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 in the trade equations indicates that trade among heterogeneous trading partners increases with overall export activity. For inward FDI the variable turns out to be statistically insignificant, the same also accounts for the proxy of relative factor endowments RLF. The inclusion of a set of endowment base variables in the FDI equations (including the host country wage rate, as well as proxies for FDI agglomeration forces, for details see e.g. Borrmann et al., 2005) 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 case they turn

[15] Calculations are based on the the 1.step single equation post estimation tests reported in Mitze et al. (2008).

[16] Also Markusen & Maskus (1999) and Carr et al. (2001) among others report a significant negative influence of distance on outward FDI / foreign affiliate production.

out to be statistically significant.

For export activity the EMU dummy shows the a-priori expected positive impact on German exports for both estimators: That is, from 1999 onwards German export activity to the other EMU member states is estimated to be above its 'normal' potential (in terms of being adjusted for economic mass, geographical distance and other explanatory variables as specified in the gravity model of eq.(1)). For inward FDI we find similar investment enhancing effects of EMU creation. Thereby the results are found to be robust for both the HT and FEVD estimator. However, on the contrary the effect 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). For imports the estimated EMU coefficient turns out to be insigificant in the HT-case and only marginally negative in the FEVD-SUR approach. Also, with respect to the border dummy we do not find any statistically significant result for both estimators.

The dummy variables for the East German states and CEEC economies turn out to be strongly negative in most specifications. Especially for the export for outward FDI equation the East German states dummy is found to be significantly negative indicating that the macro region is still far beyond its trading potential that we would expect according to their economic mass and their geographical location within the EU27.[17] 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 significantly lowered the regional user costs of capital and led to an inflow of (foreign and West German) capital.

With respect to the export equation the results for the CEEC dummy are somewhat mixed: While the HT model gets a (weakly significant) negative CEEC dummy, 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 their 'normal' potential, which has been widely confirmed in earlier empirical

[17] 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.

contributions for the first half of the 1990s.[18] On the contrary, the CEEC dummy in the outward FDI equation is found to be significantly negative for both estimators indicating that German outward FDI stocks in these economies are still below their 'normal' potential. Moreover, the persistently negative CEEC dummy in the import and inward FDI equation reflect our a-priori expectations that these countries - due to historical and structural reasons - still have very limited capacities to export and invest abroad.

<< insert Table 5 and 6 about here >>

Turning to the postestimation tests we first check for the robustness and appropriateness of the applied system estimators, which may allow us 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 likely estimation bias and weak instrument problem. We therefore compute a 'weak identification' test to measure the degree of instrument correlation with the endogenous regressors to identify low correlation levels, which in turn may translate into a poor overall performance (see e.g. Stock & Yogo, 2005). Here we use the Kleinbergen-Paap Wald F-statistic as a robust generalization of the standard Cragg-Donald-based weak identification test.[19] 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. The results of the overidentification test indicate that except for the inward FDI model all equations have rather low test statistics.[20] 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

[18]It remains an open discussion though whether this result is also expected to hold for the rapid economic catching up process of the CEECs. Moreover it is not clear whether Germany is likely 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.

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

[20]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.

also Mitze, 2008). However, for the inward FDI equations all attempts to further reduce the number of moment conditions above those reported in table 5 result in a break down of most variable coefficients. Though some caveates may apply, for the latter equation we rely on the reported IV set even though it fails to pass the Sargan overidentification test.

To compare the appropriateness of our chosen full information system approach relative to a limited information benchmark, we employ the Hausman (1978) m-statistic. The underlying idea of the test is quite simple: Under the assumption that the 3SLS estimator 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 3SLS is efficient. Under the alternative hypothesis only 2SLS is consistent.[21] 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 5 and table 6 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 imports. In sum we take these results in favour for our specified full information techniques.

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 parameter vector of the time-varying variables, we can employ the test proposed by Baltagi et al. (2003) analogously here. However, the Hausman m-statistic can not discriminate among the estimates of 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 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 6. The results indicate that the difference between the two estimators is rather small for the import and inward FDI equation, where the

[21] 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.

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, overall 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 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 basically 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 support our findings of efficient full information estimation (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 estimates, which however are qualitatively broadly in line with the Hausman-Taylor results.[22] In table 7 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 7 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

[22] Results for the latter estimator can be obtained upon request from the authors.

FDI activity in line with earlier evidence reported 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:

- West Germany - EU27,
  - West Germany - EU15,
- East Germany - EU27,
  - East Germany - EU15.[23]

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 gradual 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 8 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 intra industry trade and horizontal FDI between West Germany and the EU27 economies 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 9 even reveals complementaries among export and FDI activity, which have not been

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

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 10 and 11 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. 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) our results show that also the regional perspective within national trade and FDI activity can be of great importance in identifying cross-variable linkages.

<< insert Table 8 to 11 about here >>

5 Conclusion

The aim of this paper was to analyse 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 continued interest both in the academic literature as well as in the policy debate. Earlier evidence for (West) Germany reports negative export and outward FDI linkages (see Jungmittag, 1995, as well as Egger & Pfaffermayr, 2004). 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 strategy for a simultaneous equation trade-FDI system. We 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.

With respect to the 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 with 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.[24] 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 indicate that it seems promising to explicitly incorporate the regional perspective in order to properly model trade and FDI patterns and to identify underlying cross-variable linkages.

Methodological extensions to our work may potentially account for dynamic adjust-

[24] 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.

ment processes in the model specification (see e.g. Anderson & Hsiao, 1981, Arellano & Bond, 1991, or Blundell & Bond, 1998, for its theoretical basis) and extend 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) in terms of a robustness test of our empirical results.

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Table 1: Data description and source

Variable name	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 L"ander (Statistical office of the German states)
GDP_{jt}	Gross Domestic Product, nominal values, in Mio.	EUROSTAT
POP_{it}	Population, in 1000	VGR der L"ander
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}	$RLF = log\left\|\left(\frac{GDP_{it}}{POP_{it}}\right) - \left(\frac{GDP_{jt}}{POP_{jt}}\right)\right\|$	see above
EMP_{it}	Employment, in 1000	VGR der L"ander
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 L"ander
$KBLC_{it}$	$KBLC_{it} = \left(\frac{K_{it}}{POP_{it}}\right)$	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 L"ander
$WAGE_{jt}$	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, calculation tool 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 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
EX_{ijt}	813,08*** (0,00)	842,63*** (0,00)
$FDIout_{ijt}$	853,27*** (0,00)	687,85*** (0,00)
IM_{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)

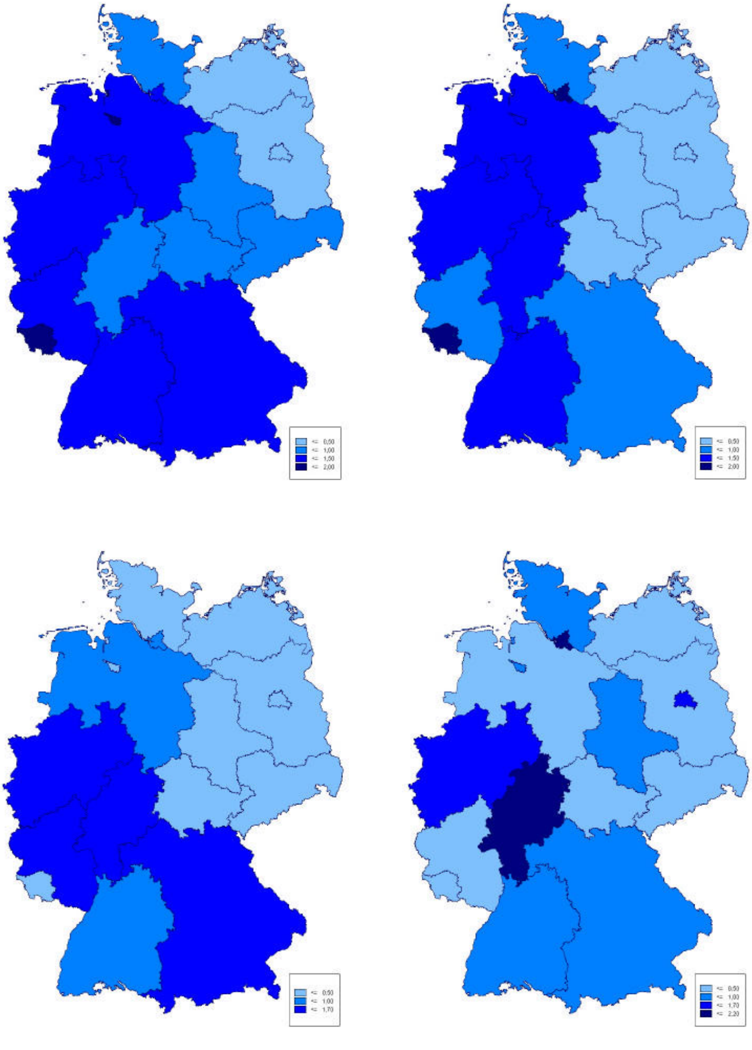
Note: The tests have been performed using the *xtfisher* Stata-routine written by Merryman (2005) and the *pescadf* routine by Lewandowski (2007).

Table 3: 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 1: Regional trade and FDI intensities within the EU27 for average 2000-2005 (with upper left: Exports, upper right: Imports, lower left: outward FDI, lower right: inward FDI)



Source: See table 3.

Table 4: 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 5: 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 bilateral 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 label the equation number as 1=export, 2=outward FDI, 3=imports, 4=inward FDI. Endogeneity of $Z2$ variables is tested based on the C-Statistic.

Table 6: 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 7: 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 8: 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 9: 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 10: 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 11: 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.

A IV and non-IV system estimators

A.1 The general model

The gravity models used throughout the paper can be written in the following general triple indexed form (much in line with Cheng & Wall (2002), Serlenga & Shin (2006) or Egger & Pfaffermayr (2004) as:

$$y_{ijt} = \alpha + \beta' X_{ijt} + \gamma' Z_{ij} + u_{ijt} \qquad \text{with:} \quad u_{ijt} = \mu_{ij} + \nu_{ijt}, \tag{5}$$

with $i = 1, 2, \ldots, N$; $j = 1, 2, \ldots, M$ and $t = 1, 2, \ldots, T$. The endogenous variable (y_{ijt}) and the vector of time varying explanatory variables (X_{ijt}) may vary in all three dimensions of our model, while the vector of time fixed explanatory variables (Z_{ij}) is kept constant across t. 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} 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. For system estimation we may write eq.(5) compactly as:

$$\begin{aligned} y_n &= R_n \xi_n + u_n \\ u_n &= \mu_n + \nu_n, \end{aligned} \tag{6}$$

where n denotes the n^{th} structural equation of the system with $n = 1, \ldots, M$. 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:

$$y_* = R_* \xi + u_*, \tag{7}$$

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

$$R_* = \begin{bmatrix} R_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & R_M \end{bmatrix} \tag{8}$$

Depending on the type of estimator we can make use of Zellner's (1962) seemingly unrelated regression (SUR) approach or 3SLS estimation to the stacked system in eq.(7). Thereby, the SUR model 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 and - if the disturbance terms are correlated - it is asymptotically more efficient than OLS for each single equation. However, for the case we have to cope with endogeneity of the right-hand side regressors of the model either in the sense of endogenous variables as explanatory variables in other equations of the system or a correlation of some regressors with the disturbances, Baltagi (2008) proposes to use 3SLS for estimating eq.(7).

A.2 The HT-3SLS-GMM estimator

Since the logic of the Hausman-Taylor model centers around consistent IV estimation of all parameters in the model, the 3SLS estimator is the natural choice (or in a broader context system GMM).[25] 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:

$$\hat{\beta}_{3SLS-GMM} = [R_*' H_* (H_*' \hat{\Omega} H_*)^{-1} H_*' R_*]^{-1} R_*' H_* (H_*' \hat{\Omega} H_*)^{-1} H_*' y_*, \tag{9}$$

where H_*^S is the system's total IV set based on the definition $H_i^S = I_M \otimes H_i$ (with H_i as the n^{th} equation instrument set) and $u_i^S = (u_{1i}', \ldots, u_{M,i}')$, so that we can write the system's overall set of moment conditions compactly as $E(H_i^{S\prime} u_i^S) = 0$. The latter in turn is chosen according to th Hausman-Taylor assumptions. $\hat{\Omega} = Cov(u_*)$ is the variance-covariance matrix of the equation system. 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

[25] 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).

equations based on a series of Hansen (1982)/Sargan (1958) overidentification tests for the single equation benchmark models.[26]

For convenience and in line with the mainstream literature on the Hausman-Taylor model we assume that Ω_* takes the random effect form.[27] We thus model the two error components μ and ν 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):

$$\Omega_{ij}^{-1/2} = (\Sigma_\nu + T_{ij}\Sigma_\mu)^{-1/2} \otimes P + \Sigma_\nu^{-1/2} \otimes Q. \tag{10}$$

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

$$\hat{\sigma}^2_{\nu_{(j,l)}} = \frac{\hat{u}'_{j,l} Q \hat{u}_{j,l}}{\sum_{i=1,j=1}^{NM}(T_{ij} - 1)}, \tag{11}$$

$$\hat{\sigma}^2_{\mu_{(j,l)}} = \frac{\hat{u}'_{j,l} P \hat{u}_{j,l} - NM\hat{\sigma}_{\nu_{(j,l)}}}{\sum_{i=1,j=1}^{NM}(T_{ij})}, \tag{12}$$

where $\hat{u}$ is the estimation residual from an untransformed 1.step 2SLS estimation (see also Baltagi, 2008, or Baltagi & Chang, 2000, for details).[28]

A.3 The FEVD(-SUR) estimator and boostrapping standard errors

An alternative to the Hausman-Taylor IV-estimator is an augmented FEM approach proposed by Plümper & Tröger (2007) for the single equation case. The goal of the so-called Fixed Effects Vector Decomposition (FEVD) model is to run a consistent FEM model

[26] Results are reported in Mitze et al. (2008) or can be obtained upon request from the authors

[27] 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

[28] Finally, in the system transformation process we follow Baltagi (2008) and apply the Cholesky decomposition to Σ_ν^{-1} and Σ_μ^{-1}.

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. The estimator builds on the following steps: First, we apply a standard FEM on eq.(5) 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-fixed variables against this 'generated regressand' as:

$$\hat{\mu}_{ij} = \omega + \hat{\delta}' Z_{ij} + \eta_{ij}, \tag{13}$$

where ω is an overall intercept and η_{ij} is the residual. The second step aims at identifying the unobserved parts of the individual effects. In a third (optional) step Plümper & Tröger re-estimate eq.(5) 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. Finally, it is important that standard errors 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.

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 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 form that non of the time-fixed variable is correlated with the individual effects.[29] 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. However, Monte Carlo simulations by Alfaro (2006), Plümper & Tröger (2007) and Mitze (2008) 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

[29] 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.

prediction errors than consistent Hausman-Taylor specification especially for estimating the coefficients of both endogenous and exogenous time-fixed variables.

As outlined in section 4, the system extension to the FEVD is rather straightforward. To correct standard errors in the resulting FEVD-SUR approach we apply the 'wild bootstrap' technique, which is implemented through the following steps as outlined in Atkinson & Cornwell (2006):[30]

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

$$\hat{\pi}_i = \bar{y} - \hat{\beta}_{FEM-SUR}\bar{X}_i \tag{14}$$

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

Step 4: Compute the second step residuals as

$$\hat{\xi}_{it} = y_{it} - \hat{\beta}_{FEM-SUR}X_{it} - \hat{\gamma}_{POLS-SUR}(J_T \otimes Z_i) \tag{15}$$

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

$$f(\hat{\xi}_{it})\tilde{\upsilon}_{it} \text{ where } f(\hat{\xi}_{it}) = \frac{\hat{\xi}_{it}}{(1-h_{it})^{1/2}} \tag{16}$$

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); $\tilde{\upsilon}_{it}$ is defined as a two-point distribution (the so-called Rademacher distribution) with

$$\tilde{\upsilon}_{it} = \begin{cases} -1 \text{ with probability } 1/2 \\ -1 \text{ with probability } 1/2 \end{cases} \tag{17}$$

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

Step 6: Generate

$$y^*_{it} = \hat{\beta}_{FEM-SUR}X_{it} - \hat{\gamma}_{POLS-SUR}(J_T \otimes Z_i) + \tilde{\upsilon}^*_{it} \tag{18}$$

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

[30] 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

$$\omega_i = \bar{\tilde{\xi}}_i - (\hat{\beta}^*_{FEM-SUR} - \hat{\beta}_{FEM-SUR})\bar{X}_i \tag{19}$$

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

$$\pi^*_i = \hat{\gamma}_{POLS-SUR} Z_i + u^*_i \tag{20}$$

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 $\hat{\gamma}_{POLS-SUR}$.

B Testing for cross-equation residual correlation

In order to analyse the statistical significance of the identified 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).[31] The Breusch-Pagan LM test on the correlation of individual effects across equations can be defined as

$$BP = \left(\frac{1}{2}\right) n^2[A^2/(J-n)], \quad \text{with:} \quad \begin{aligned} J &= \sum_{i=1,j=1}^{NM} T_{ij} \times (T_{ij} - 1), \\ A &= [(u_j \Delta_1 \Delta_1' u_l)/((u_j' u_j)(u_l' u_l))^{1/2}], \\ \Delta_1 &= (D_1', D_2', \ldots, D_T')', \end{aligned} \tag{21}$$

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 (with j, l = [exports, FDI out, imports, FDI in]). 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). Under the null hypothesis of no correlation, the Breusch-Pagan type LM test given by eq.(21) is asymptotically distributed as $\chi^2(1)$.

[31] 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.