TRADE SPECIALISATION AND ECONOMIC CONVERGENCE: EVIDENCE FROM TWO EASTERN EUROPEAN COUNTRIES

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Abstract

This paper analyses trade specialisation dynamics in two Eastern European countries (Romania and Bulgaria – EEC-2) vis-à-vis the core EU member states (EU-15) over the period 1990-2006. Specifically, we focus on whether there is a shift towards intra-industry trade leading to economic convergence and technological catch-up. We use recently developed static (FEM, REM and FEVD) and dynamic (GMM) panel data methods which take into account possible heterogeneity. Our empirical results indicate that intra-industry trade has indeed increased, but it is of the vertical rather than the horizontal type, resulting in complementary rather than competitive production patterns.

Keywords: gravity models, panel data models, trade specialisation, comparative advantage

JEL Classification: F13, F15**,** C23.

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1. Introduction

Even after Romania and Bulgaria, two Eastern European countries (EEC-2 henceforth), became EU members in 2007, long-term economic convergence has remained an important goal for them (Albu, 2008; Iancu, 2008). The EU enlargement, by bringing together developed and transition economies, is generally expected to lead to higher intra-industry trade through technology transfers, and therefore to economic convergence, which is typical of regionalisation (see Lundberg, 1992; Fontagné and Freudenberg, 1997, Fidrmuc and Djablík 2003). Economic integration also leads to the international diffusion of knowledge and convergence in the quality of traded goods, with a positive effect on exports (Cavallaro and Mulino, 2008). There is in fact a wide consensus in the literature that intra-industry trade is more conducive to economic growth than inter-industry trade, and that the former tends to take place between countries with similar factor endowments (Helpman, 1987), to stimulate innovation and to exploit economies of scale (Ruffin, 1999). Given the fact that there is a positive correlation between GDP growth and intensity of intra-industry trade, new EU members hope to achieve higher growth rates and sustainable development as a result of an increase in intra-industry trade with the other members.

International trade specialisation reflects differences in relative factor productivity and endowments, economies of scale or specific advantages of firms. It is not neutral, and it can have a significant impact on economic growth. Countries that converge normally export products whose share in international trade is increasing. By contrast, those diverging typically exhibit inertia, and have comparative advantages in products whose share of world trade is stable or declining. Competitiveness is primarily a result of comparative advantages at the microeconomic level as well as of product innovation and differentiation.

This paper analyses trade specialisation dynamics of a set of heterogeneous economies by exploiting recent advances in panel data econometrics. Our sample includes data on the EU-15 (the core of the EU) and the EEC-2, which have many similarities and entered the EU as part of the last wave of 2007. The issue of interest is whether EU membership has resulted in the EEC-2 continuing to specialise in inter-industry trade based on their comparative advantage resulting from lower labour costs, or instead their moving towards intra-industry specialisation which leads to economic convergence. Although convergence towards the other EU-15 members is the aim of the EEC-2 countries, significant differences in labour costs and technological level[1] may lead to a reallocation of labour-intensive industries from the EU-15 to the EEC-2 as part of the international division of the production process.

Our empirical analysis over the period 1990-2006 is based on economic indicators and the econometric estimation of a gravity model, which is suitable for both intra- and inter-industry trade. We use recently developed static and dynamic panel data methods, which explicitly take into account unobserved heterogeneity. Specifically, we use the fixed effect and random effect models (FEM and REM respectively) as well as the fixed effect vector decomposition (FEVD) technique proposed by Plümper and Troeger (2004), and the system Generalized Moment Method (GMM) estimator developed by Arellano and Bover (1995) and Blundel and Bond (1998). First, we highlight the existence of strong asymmetries in trade relationships between the countries of the two groups (EU-15 and EEC-2). Then we select an appropriate specification of the gravity model and carefully investigate the main determinants of trade flows between these sets of countries.

The remainder of the paper is organised as follows. Section 2 provides some background information on trade flows between the EEC-2 and the EU-15. Section 3 outlines the theory behind gravity models. Section 4 presents the econometric model and reports the empirical results. Finally, Section 5 summarises the main findings and discusses their policy implications.

2. An overview of trade flows between the EEC and EU-15 countries

Trade patterns between the EEC and the EU-15 countries are still characterised by significant asymmetries which are a heritage of the former communist system which followed an extensive rather than intensive development policy: until 1989, the former group of countries were centrally planned economies where trade was based on monopoly of international trade, import and export planning and currency inconvertibility. Hence, trade mainly took place within the Council for Mutual Economic Assistance. After the fall of the communist regime, these countries adopted instead an open system and Western Europe became one of their most important trade partners. However, trade openness towards Western Europe varied significantly, the relevant index in 1989 being 19.3% for Romania and 18.4% for Bulgaria respectively. This reorientation of trade flows towards Western Europe is consistent with the gravity model. Geographical, historical and cultural links played an important role in the

[1] In 2005, hourly labour costs were equal to 2.33 euros in Romania, 1.55 euros in Bulgaria and 25.1 euros in the EU-15 (source: Eurostat).

establishment of preferential relationships between the two zones. We are interested in analysing the evolution of trade patterns for the EEC-2 countries since they obtained access to a much wider market.

2.1 Increasing but asymmetric trade flows

The framework for trade flows between the EEC-2 and EU-15 is given by the European Agreement of 1993. Its implementation has led to a significant increase in trade volume between these two sets of countries, with both higher exports and imports (see Figure 1, and Table 1 for country and sector codes). In Romania, the trade balance moved from a surplus to a deficit in 1992, and the latter grew over time. Bulgaria has experienced a deficit throughout (see Figure 1 and Table 5). By 2000, weights for trade flows to/from the EU-15 were very close to those for intra-European trade. However, the East-West relationship is asymmetrical as the EEC-2 only play a marginal role in total trade of the EU-15 while the latter are their main partner. The trade deficit reflects a lack of competitiveness of the EEC-2 products compared to the EU-15 ones.

2.2 The reorientation of EEC trade and structural adjustment

Next, we examine whether the reorientation of trade towards the EU-15 was accompanied by industrial structural adjustment and convergence of trade specialisation. As can be seen from Figure 2, which shows export weights to the EU-15 by sector, in Romania some sectors (textiles, electric and mechanics) experienced a sharp increase in exports, whilst other did not. In Bulgaria, the textiles and steel sectors were most successful.

Thus, international trade in the case of the EEC-2 still concerns labour-intensive industries. In Romania the weight for exports of the textile sectors has increased from 28.2% in 1990 to 37.1% in 2006; in Bulgaria it has risen from 16.2% to 29.1% over the same time period. In 1990, in Romania the weights were the following: 21.4% (energy sector), 28% (textiles), 19.9% (woods and paper), 9.3% (electric and mechanics), 5.4% (chemicals), and 2.4% (building materials, agricultural products and food). The figures for 2006 indicate clearly the key role of low labour costs as a comparative advantage, the new weights being: 37% (textile sector), 34.8% (electric and mechanics sector). Therefore, reallocations concerned primarily the textile sector, followed by the electric and mechanics sector, where segments of production with assembly operations were particularly developed. The recent increase in the volume of electric and mechanics exports may lead to an improvement in

Romanian exports to the EU-15, but in general trade remains based on inter-sectoral complementarity. The weights of other sectors have instead declined since 1990: for iron and steel from 8% to 5.4%, for the energy sector from 21.4% to 2%, for the woods and paper sector from 19.9% to 9.1%, for the chemicals sector from 5.4% to 5.1%, and for food products from 2.4% to 0.8% (see Figure 2 and 3).

A similar evolution can also be observed in Bulgaria, where the weight of the textile sector has increased from 16.2% (in 1990) to 29.1% (in 2006), that of the iron and steel sector from 13.2% to 23.5 %, and that of the electric and mechanic sectors from 12% to 18.8%. In the other sectors there has been a fall of about 1%. This can be seen as evidence of complementary specialisation.

2.3 Trade specialisation of the Eastern European Countries

To shed further light on trade specialisation, we analyse some indicators of (i) comparative advantage and (ii) intra-industry trade.

2.3.1 Comparative advantages of the EEC

The analysis of sectoral trade adjustment is based on revealed comparative advantages calculations. Their evolution over time indicates whether trade pattern convergence has occurred.

Balassa (1965) was the first to propose indicators based on trade to measure international specialisation indirectly: he suggested to use export and import flows, and the trade balance. Here we utilise the indicator due to Lafay (1990), where the trade balance is weighted by a country's GDP:

$$Ack = (\frac{1000}{PIB})\frac{2 \times (X_{ik}M - XM_{ik})}{X + M} \qquad (1)$$

where:

A_{ck} = Lafay indicator;

X, M = total exports and imports;

X_{ik}, M_{ik} = exports and imports of product k;

PIB = gross domestic product.

This indicator measures the relative contribution of product k to the overall trade balance. A positive (negative) sign indicates the existence of a comparative advantage (disadvantage).

Table 2 shows that trade patterns are relatively stable after 17 years of economic catch-up. The most important comparative advantages concern the labour-intensive products, in particular textile products, footwear, wood and paper products. These advantages have increased over time as a result of subcontracting from the EU-15 to the EEC-2, where wages are much lower. The textiles sector appears to have the strongest comparative advantage and the highest degree of specialisation. Generally, capital-intensive sectors have a comparative disadvantage. An example is the electric and mechanic sector, which has a greater disadvantage in Bulgaria than in Romania.

Overall, what emerges from the sectoral analysis is that the comparative advantages of Romania and Bulgaria vis-à-vis the EU-15, and their specialisation, are based on differences in factor endowments. Trade specialisation for the two countries reflects a relatively large and increasing weight of labour-intensive products. Over time, there have been no major changes in export products, and technology-intensive industries with highly-skilled labour have not become competitive.

2.3.2 Intra-industry trade and competitive pressures

International trade does not result only from comparative advantages, which imply export and import flows of complementary products, i.e. inter-industry trade (IT), in accordance with classical theory. Intra-industry trade (IIT) also occurs, with simultaneous export and import flows of comparable size within the same industry; this can be either horizontal or vertical. The former is typical of developed countries and is two-way trade in a single industry between products at the same stage in the production process. Vertical intra-industry trade (VIIT) instead concerns products at different stages of the production process.

Generally, regional integration of different economies leads to higher inter-industry trade (IT) based on complementary products but also to vertical intra-industry trade with specialisation in different segments of the production process, with a different unit cost. In our case, it is interesting to establish whether there has been an increase in intra-industry trade for the EEC-2 (Romania and Bulgaria). This is normally associated with economic catching-up, and would indicated integration of EU industrial patterns and hence convergence between the EEC-2 and the EU-15. A widely used measure of intra-industry trade is the traditional Grubel-Lloyd (GL) (1975) indicator. When this index is close to 1, intra-industry trade dominates, whilst, when the coefficient is close to 0, trade is predominantly of the inter-industry type.

The GL indicator is defined as follows:

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$$. GL = 1 - \frac{\sum_{k=1}^{N} \left| X_{ijkt} - M_{ijkt} \right|}{\sum_{k}^{N} (X_{ijkt} + M_{ijkt})} \qquad (2)$$

where :

X^k_{ijt} = exports of product industry ***k*** of country ***i*** towards country ***j*** in year ***t***

M^k_{ijt}= imports of product ***k*** country ***i*** from country ***j*** in year ***t***

A high share of intra-industry trade suggests advanced economic integration and a high level of industrial development, and can have significant long-term benefits. However, intra-industry trade by itself is not sufficient to characterise the level of technological development and competitiveness, an essential condition to cope with competitive pressures. Indeed, empirical studies have highlighted the existence of two types of intra-industry trade: horizontal and vertical. Trade with horizontally differentiated products is specific to countries which have a high level of development, with high prices incorporating research and development (R & D) costs and significant value added. Vertical intra-industry trade is specific to less developed countries, and it leads to specialisation in less capital-intensive production stages.

We find (see Table 3a and 3b) a sharp increase in the GL index during the period under investigation, which indicates a growing importance of intra-industry trade, which by 2006 has become dominant, although the index itself does not allow us to distinguish between vertical and horizontal intra-industry trade.

The GL index is a static measure as it captures IIT in one particular year. There is a wide consensus in the literature that IIT entails lower costs of factor market adjustment than inter–industry trade (Balassa 1966). To analyse the dynamic adjustment we use the marginal intra-industry trade (MIIT) measure developed by Brülhart (1994), which is the following:

$$A = 1 - \frac{|\Delta X - \Delta M|}{|\Delta X| + |\Delta M|} \qquad (3)$$

The MIIT, as the GL index, varies between 0 and 1, with 0 (1) indicating that marginal trade is entirely of the inter-industry (intra-industry) type.

However, Brülhart's (1994) dynamic index also does not distinguish between vertical and horizontal IIT. To resolve this issue we adopt the method proposed by Thom and McDowell (1999), which differentiates between horizontal and vertical IIT on the basis of the organisation of production rather than goods characteristics. By assuming that industry J has

N sub-industries the following index for horizontal intra-industry (HIIT) can be derived:

$$A_w = \sum_{i=1}^{N} w_i A_i \qquad (4)$$

where :

A_i represents Brülhart's marginal intra-industry trade index for product i of industry j;

$$A_i = 1 - \frac{|\Delta X_i - \Delta M_i|}{|\Delta X_i| + |\Delta M_i|} \qquad (5)$$

X_i = value of export of product i ; M_i= value of import of product i

$\Delta X = X_t - X_{t-n}$ and $\Delta M = M_t - M_{t-n}$ (the difference of export/import between year t and t-n)

w_i are appropriate weights (see Brülhart 1994) defined as :

$$w_i = \frac{|\Delta X_i| + |\Delta M_i|}{\sum_{i=1}^{N}\left(|\Delta X_i| + |\Delta M_i|\right)} \qquad (6)$$

where $X_j = \sum_{i=1}^{N} X_i$ and $M_j = \sum_{i=1}^{N} M_i$ and A_j (the proportion of matched two-way trade at the industry j level) is given by

$$A_j = 1 - \frac{|\Delta X_j - \Delta M_j|}{\sum_{i=1}^{N}|\Delta X_i| + \sum_{i=1}^{N}|\Delta M_i|} \qquad \mathbf{(7)}$$

A_j represents vertical and horizontal intra-industry trade. Vertical IIT is given by A_j-A_w while inter-industry trade (IT) is measured by (1-A_j). Our results highlight a shift towards intra-industry trade, especially of the vertical type in the last period (see Table 4a, b).

Next, in order to shed more light on the type of specialisation of these two countries vis-à-vis the EU-15 we carry out static and dynamic panel data analysis and estimate a gravity model, whose theoretical foundations are outlined in the next section.

3 The gravity model

The gravity model is widely used as a benchmark to estimate trade flows between countries [2]. Trade flows from country ***i*** to country ***j*** are modelled as a function of supply of the exporter

[2] Eichengreen and Irwin (1995) consider the gravity model "the workhorse for empirical studies of regional integration".

country, demand of the importer country and trade barriers. In other words, national incomes of two countries, transport costs (transaction costs) and regional agreements are the basic determinants of trade.

Initially inspired by Newton's gravity law, gravity models have become essential tools in the analysis of international trade flows. The first applications were rather intuitive, without theoretical foundations. These included the contributions of Tinbergen (1962) and Pöyhönen (1963). Subsequently, new international trade theory provided theoretical justifications for these models in terms of increasing returns of scale, imperfect competition and geography (transport costs) (see Anderson 1979, Bergstrand 1985, and Helpman and Krugman 1985).

Linnemann (1966) proposed a gravity model based on a Walrasian, general equilibrium approach. He explained exports of country ***i*** to country ***j*** in terms of the interaction of three factors: potential supply of exports of country ***i***, potential demand of imports from the country ***j***, and trade barriers. Potential export supply is a positive function of the exporting country's income level and can also be interpreted as a proxy for product variety. Potential import demand is a positive function of the importing country's income level. Barriers to trade are a negative function of trade costs, transport costs, and tariffs.

Bergstrand (1989) also included per capita income, which is an indicator of demand sophistication (demand for luxury versus necessity goods), and incorporated factor endowment variables in the spirit of Heckscher-Ohlin and taste variables in the spirit of Linder:

$$PX_{ij} = \Psi_0 (Y_i)^{\Psi_1} \left(Y_i / L_i \right)^{\Psi_2} \left(Y_j \right)^{\Psi_3} \left(Y_j / L_j \right)^{\Psi_4} \left(D_{ij} \right)^{\Psi_5} \left(A_{ij} \right)^{\Psi_6} e_{ij} \qquad (8)$$

where PX_{ij} represents flows from country i to country j, β_0 is the intercept, Y_i and Y_j are the GDP of country i and j respectively, (Y_i / L_i) and (Y_j / L_j) stand for GDP per capita of country ***i*** and ***j*** respectively, D_{ij} represents the geographical distance between the economic centres of two partners, A_{ij} factors aiding (e.g., common language and historical bonds) or representing a barrier to trade between partners.

The gravity model has been widely used in the applied literature to evaluate the impact of regional agreements (see Frankel, 1997; Carrère, 2006; Rault, Sova and Sova, 2008, Caporale et al., 2008), the border effect on trade flows (Anderson and Van Wincoop, 2003), and to simulate trade potential (Baldwin, 1994; Peridy, 2005a).

4. Econometric analysis

4.1. Methodological issues

The gravity model is the theoretical underpinning of the econometric framework we adopt. As heterogeneity plays an important role in bilateral flows, individual fixed effects are introduced into the empirical model to take it into account. One can also examine the evolution over time of countries' behaviour through temporal fixed effects (economic or political events).

Most studies estimating a gravity model apply the ordinary least square (OLS) method to cross-section data. Several papers have argued that standard cross-section methods lead to biased results because they do not take into account heterogeneity (e.g., historical, cultural and linguistic factors). Panel data methods are therefore preferable as they enable one to control for specific effects (such as fixed or random effects), and hence eliminate the potential endogeneity bias resulting from unobserved individual heterogeneity.

Matyas (1997) stresses that the cross-section approach is affected by misspecification and suggests that the gravity model should be specified as a "three-way model" with exporter, importer and time effects (random or fixed ones). Egger and Pfaffermayr (2003) underline that the omission of specific effects for country pairs can bias the estimated coefficients. An alternative solution is to use an estimator to control bilateral specific effects as in a fixed effect model (FEM) or in a random effect model (REM). The advantage of the former is that it allows for unobserved or misspecified factors that simultaneously explain the trade volume between two countries and lead to unbiased and efficient results.

Plümper and Troeger (2004) have proposed a more efficient method called "the fixed effect vector decomposition (FEVD)" to accommodate time-invariant variables. Using Monte Carlo simulations, they compared the performances of the FEVD method to some other existing techniques, such as the fixed effect, or random effect, or the Hausman-Taylor methods. Their results indicate that the most reliable technique for small samples is FEVD if time-invariant variables are present and the other variables are correlated with specific effects, which is likely to be the case in our study (see the Appendix for more details).

In addition to FEM, REM, and FEVD, that are static panel data methods, we also use the Generalized Method of Moments (GMM) for dynamic panels of Arellano and Bover (1995) and Blundel and Bond (1998). This involves estimating a system containing both first–differenced and levels equations, providing a solution to problems such as simultaneity bias, inverse causality and omitted variables. Besides, this method controls for individual specific and time effects overcomes endogeneity bias. The model is well specified if the estimator is consistent (based on the Arellano-Bond AR(2) test) and the instruments are valid on the basis of Hansen's over-identification test (more technical details can be found in the Appendix).

4.2. Econometric results

Our aim is to analyse the trade specialisation dynamics of the EEC-2 vis-a-vis the EU-15 using a gravity model. In particular, we want to investigate whether there has been an increase in intra-industry trade leading to economic convergence and to explain the trend of the share of intra-industry trade in total trade (inter- and intra-industry) between the EEC-2 and the EU-15. Following the new trade theory (Helpman, 1987, Hummels and Levinsohn, 1995), we estimate a trade equation for bilateral exports where differences in relative factor endowment ($DGDPT_{ij}$) and relative country size (RCS_{ij}) are the main determinants of the trends in the share of intra-industry specialisation. The bigger the difference between the partners' factor endowments, the lower the share of the intra-industry trade will be. The larger the measure of relative country size is, the higher the share of intra-industry trade. Helpman (1987) in fact found a positive correlation between the share of intra-industry trade and a relative country size (interpreted as empirical support for the theory of returns to scale and imperfect competition in international trade), and a negative correlation with differences in relative factor endowments. After estimating the model over the whole sample, we also consider two subsamples in order to detect any sizeable changes in the share of intra-industry trade.

Model Specification

We model bilateral exports as a function of GDP, the difference in per capita income, relative country size and geographic distance. The equation is the following:

$$X_{ijt} = e^{a_0} GDP_{it}^{a_1} GDP_{jt}^{a_2} DGDPT_{ijt}^{a_3} Dist_{ij}^{a_4} RCS_{ijt}^{a_5} \; Acc_{ijt}^{a_6} e^{u_{ij}} e^{v_t} e^{\varepsilon_{ijt}} \qquad (9)$$

where: X_{ij} denotes bilateral trade between countries ***i*** and ***j*** at time ***t*** with i # j

a_o is the intercept;

- GDP_{it}, GDP_{jt} stand for Gross Domestic Product of country ***i*** and country ***j*** (expected sign: positive)
- RCS_{ij} is relative country size defined as follows (expected sign: positive):

- $$RCS_{ijt}^{(+)} = \left[1 - \left(\frac{GDP_{it}}{GDP_{it} + GDP_{jt}}\right)^2 - \left(\frac{GDP_{jt}}{GDP_{it} + GDP_{jt}}\right)^2\right] \tag{10}$$

and 0 <Log RCS >0.5. The higher its value is, the higher the share of intra-industry trade.

- $DGDPT_{ijt}$ is the difference in GDP per capita between partners and is a proxy for economic distance or comparative advantage intensity[3] (expected sign: positive for inter- and negative for intra-industry trade)
- $Dist_{ij}$ represents the geographical distance between two countries (expected sign: negative)
- Acc_{ijt} is a dummy variable that equals 1 if country ***i*** and country ***j*** have signed a regional agreement, and zero otherwise (a positive correlation between this variable and intra-industry trade is expected)
- ε_{ijt} is the error term,
- u_{ij} is bilateral effects
- υ_t is time effects

After log-linearisation, equation (9) becomes the following in a static context:

$$Log(X_{ijt}) = a_0 + a_1 \log(GDP_{it}) + a_2 \log\left(GDP_{jt}\right) + a_3 \log\left(DGDPT_{ijt}\right) + a_4 \log\left(Dist_{ij}\right) + \\ + a_5 \log\left(RCS_{ijt}\right) + a_6 Acc_{ijt} + u_{ij} + \nu_t + \varepsilon_{ijt} \tag{11}$$

or, in a dynamic context:

$$Log(X_{ijt}) = a_0 + a_1 \log(X_{ijt-1}) + a_2 \log(GDP_{it}) + a_3 \log\left(GDP_{jt}\right) + a_4 \log\left(DGDPT_{ijt}\right) + \\ a_5 \log\left(Dist_{ij}\right) + a_6 \log\left(RCS_{ijt}\right) + a_7 Acc_{ijt} + \nu_t + \varepsilon_{ijt} \tag{12}$$

Our panel includes the EEC-2 and the EU-15 countries[4]. The data are annual, and the sample period is 1990 - 2006. The model is estimated over the whole period, and also for two subperiods (1990-1999 and 2000-2006). As a robustness check, we use all the estimation methods previously outlined.

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[3] Note that when we use GDP per capita in our estimates, we find a strong correlation between GDP of the exporting country and their GDP per capita. Consequently, we have decided to use the difference in GDP per capita between partners as a regressor.

[4] *EU-15*: Austria, Belgium, Luxemburg, Denmark, England, Finland, France, Germany, Greece, Holland, Ireland, Italy, Portugal, Spain, Sweden.

Results

The estimation results using REM, FEM and FEVD are reported in Table 6a and those using GMM and Table 6b. The results based on FEVD and FEM are similar, which indicates robustness of our estimates, and highlight the effects of the time-invariant variables on trade flows. For our static panel data analysis, FEVD is more appropriate given the sample size, and has a higher R^2, equal to 0.90 (see Table 6a).

In all cases, the variables are significant and have the expected sign, consistent with the gravity model. Access to a larger market increases trade volume. On the contrary, the distance variable (a proxy for transportation costs) reduces trade. Its elasticity is systematically high, indicating that trade flows are extremely sensitive to transportation costs.

The analysis of how specialisation has changed over time shows a shift towards intra-industry trade in the second period (see columns (6) and (9)). Owing to differences in factor endowments and relative country size inter-industry trade dominates in the first period, which was a transition period with significant economic changes and adjustments. By contrast, in the second period the negative effect of $DGDPT_{ijt}$ drives up the share of intra-industry trade (IIT). This is negatively related to economic distance and positively related to relative country size. The period from 2000 is characterised by an increasing role of multinational firms in the markets of both countries and a higher growth rate.

The GMM estimates (see Table 6b) appear to be consistent, there is no residual autocorrelation, and the validity of the instruments is confirmed by Hansen's test. The coefficients are all statistically significant and with the expected signs. Splitting the sample highlights the shift towards intra-industry trade which has occurred in the second period.

The increase of intra-industry trade is due to generally higher trade flows between the EEC-2 and EU-15 but also to the presence of vertically integrated multinational firms. Hoekman and Djankov (1996) report that higher FDI is behind increasing vertical intra – industry trade between CEEC and EU countries. In the literature, a high share of intra-industry trade is often associated to deeper economic integration between countries. Kaitila (1999) found that intra-industry trade between the transition countries and the core EU is low compared to intra-industry trade within the EU, but has increased as a result of trade pattern changes.

It is possible that the estimated share for intra-industry trade reflects vertical intra-industry trade resulting from the strategy of multinationals splitting their production process across countries. To shed light on this issue, it is necessary to analyse the imports of intermediate goods and equipment used by foreign firms for the production of final goods, which are then exported. During the period under investigation in Bulgaria and Romania there was an increase of imports of intermediate goods and equipment, especially after 2000; these exceeded 50% of total imports to the EU-15.

We are interested in establishing whether imports of intermediate goods affected exports of both countries to the EU-15: a positive impact would indicate the existence of intra-industry trade based on the international division of labour, reflecting vertical integration pursued by multinational firms, and thus interdependence between the EEC-2 and EU-15. For this purpose, we estimate a trade equation including a control variable, i.e. imports of intermediate goods and equipment, using the same dataset as before. The specification is the following:

in a static context:

$$Log(X_{ijt}) = a_0 + a_1 \log(GDP_{it}) + a_2 \log\left(GDP_{jt}\right) + a_3 \log\left(DGDPT_{ijt}\right) + a_4 \log\left(Dist_{ij}\right) + \\ + a_5 \log(M\,\mathrm{int}_{ijt}) + a_6 \log(RCS_{ijt}) + a_7 Acc_{ijt} + u_{ij} + v_t + \varepsilon_{ijt} \qquad (13)$$

in a dynamic context:

$$Log(X_{ijt}) = a_0 + a_1 \log(X_{ijt-1}) + a_2 \log(GDP_{it}) + a_3 \log\left(GDP_{jt}\right) + a_4 \log\left(DGDPT_{ijt}\right) + \\ + a_5 \log\left(Dist_{ij}\right) + + a_6 \log(M\,\mathrm{int}_{ijt}) + a_7 \log(RCS_{ijt}) + a_8 Acc_{ijt} + v_t + \varepsilon_{ijt} \qquad (14)$$

where: Mint_{ijt} = imports of intermediate goods and equipment of country ***i*** from country ***j***,

X_{ijt} = exports of country ***i*** towards the country ***j***,

The other variables are defined as before.

The results can be summarised as follows. The positive sign of the coefficient on the control variable confirms the existence of trade flows based on the international division of the production process of multinational firms of the EU-15, i.e. of vertical intra-industry trade (see Table 7). An example is the increase of Romanian and Bulgarian textile exports. The EEC-2 import quality intermediate goods from the EU-15; these are then used by foreign firms together with cheap labour for the production of final products, which are exported to the EU-15.[5] Essentially, one observes a strategy of vertical division of labour, based on the comparative advantage the EEC-2 have in labour-intensive production segments and their comparative disadvantage in capital-intensive sectors. Overall, it appears that vertical intra-industry trade dominates and largely accounts for the increase in trade flows with the EU-15.

[5] In 2005, hourly labour costs were equal to 2.33 euros in Romania, 1.55 in Bulgaria and 25.1 in the EU-15 (source: Eurostat).

Our finding of vertical intra-industry trade in the second period is consistent with previous evidence (see Kaitila, 1999). Aturupane et al. (1999), Kaitila and Widgren (1999) and Fidrmuc and Djablík (2003) report that for the CEEC the most important component of intra-industry trade is of the vertical type. Caetano and Galego (2006) found a significant decline in inter-industry trade and an increasing specialisation in vertical IIT. However, the risk for countries such as Bulgaria and Romania with labour-intensive sectors is that the development of inter-industry and vertical intra-industry trade will perpetuate trade specialisation based on the exploitation of low wages.

5. Conclusions

In this paper, we have investigated trade specialisation of the EEC-2 vis-à-vis the EU-15 over the period 1990-2006 using both static and dynamic panel data techniques which take into account heterogeneity and hence avoid biased estimates. Specifically, we have examined whether there has been a shift towards intra-industry trade, necessary for economic convergence and technological catch-up. Our empirical findings can be summarised as follows.

Trade volumes (both exports and imports) have increased significantly since the signing in 1993 of the European Agreement with the EU. In 2000, the volume of trade with the EU-15 was similar to the volume of intra-European trade, indicating trade integration. In general, exports are dominated by products with labour-intensive comparative advantages. In the period 2000-2006, there was an increase (more for Romania than for Bulgaria) of exports of products with higher value added, incorporating physical capital and skilled labour, but no significant changes in competitiveness such as to improve the trade balance.

Our results indicate a shift towards intra-industry trade, specifically of the vertical type: EU multinational firms manufacture products in Romania and Bulgaria exploiting the comparative advantage of low labour costs and then export them. This type of trade increases production and labour productivity, but does not lead to economic convergence, which is associated instead to horizontal intra-industry trade, i.e. to simultaneous export and import flows of comparable size of products with similar quality, technology and value added. In other words, in the context of European integration, the EEC-2 have followed the strategy of exploiting their comparative advantage of low labour costs in the context of the international division of production processes, although some sectors with high value added (e.g., electric and mechanics) have also expanded (similar results were reported by Andreff (1998) for other

Eastern European economies as well). Therefore, the challenge for Romania and Bulgaria is to change their production patterns from complementary to competitive and move towards international market segments with high quality and high value-added products, thereby accelerating convergence towards the EU-15.

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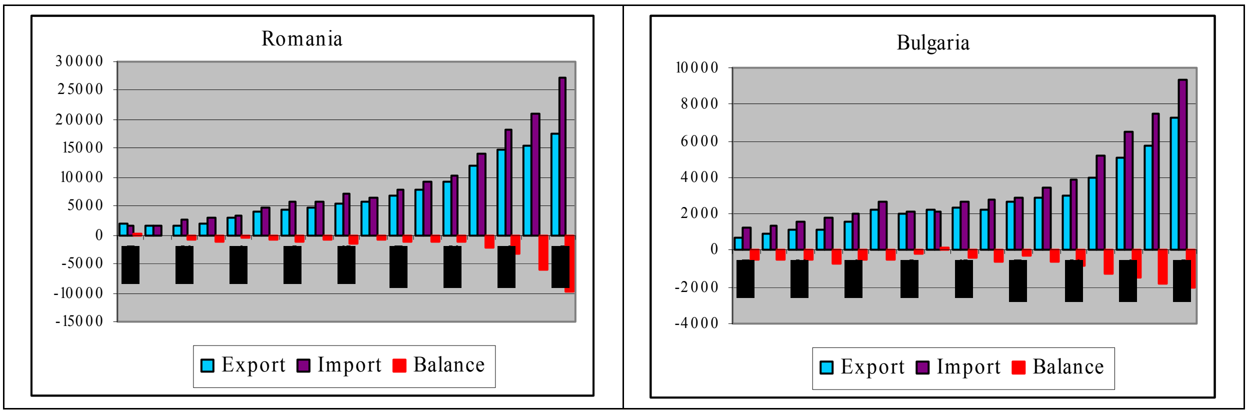
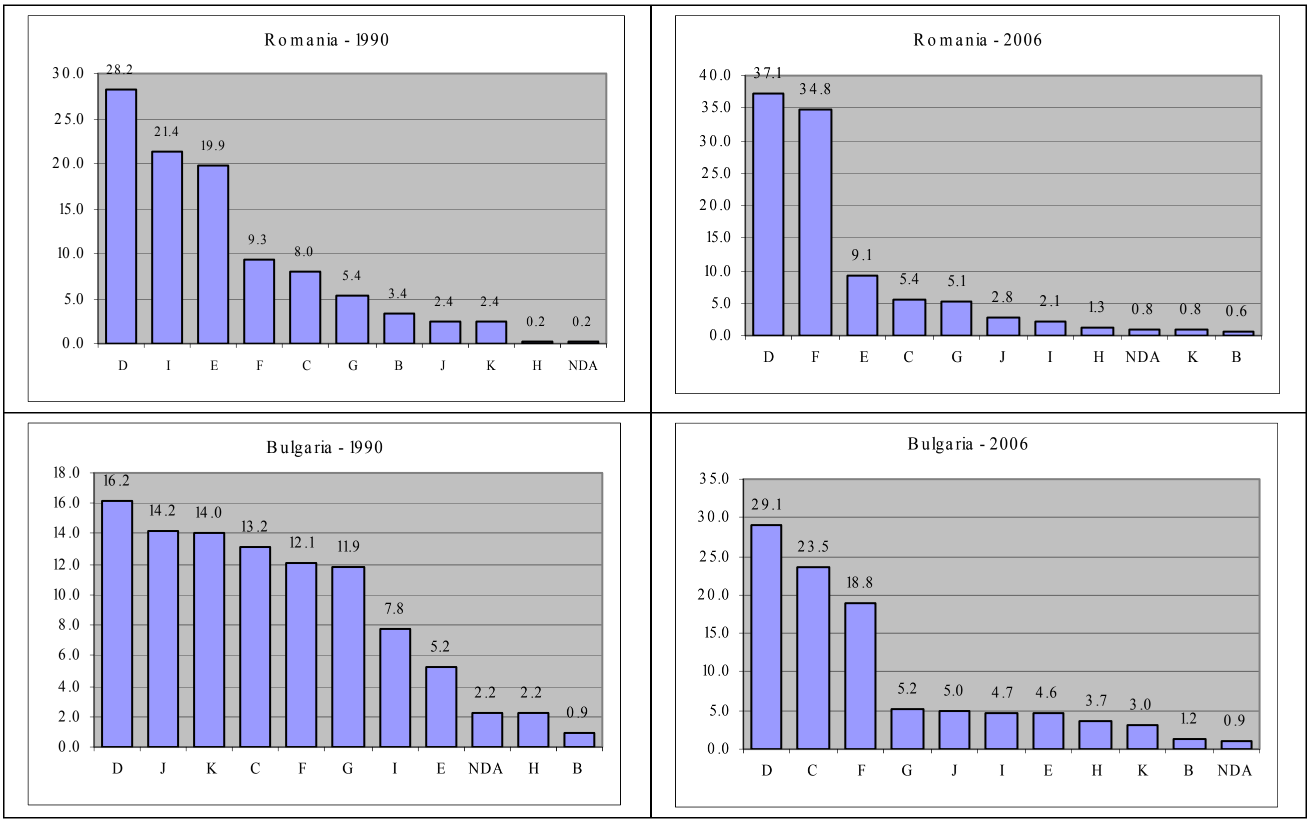
Figure 1: Exports, imports and trade balance of Romania and Bulgaria (in million dollars) 1990 → 2006



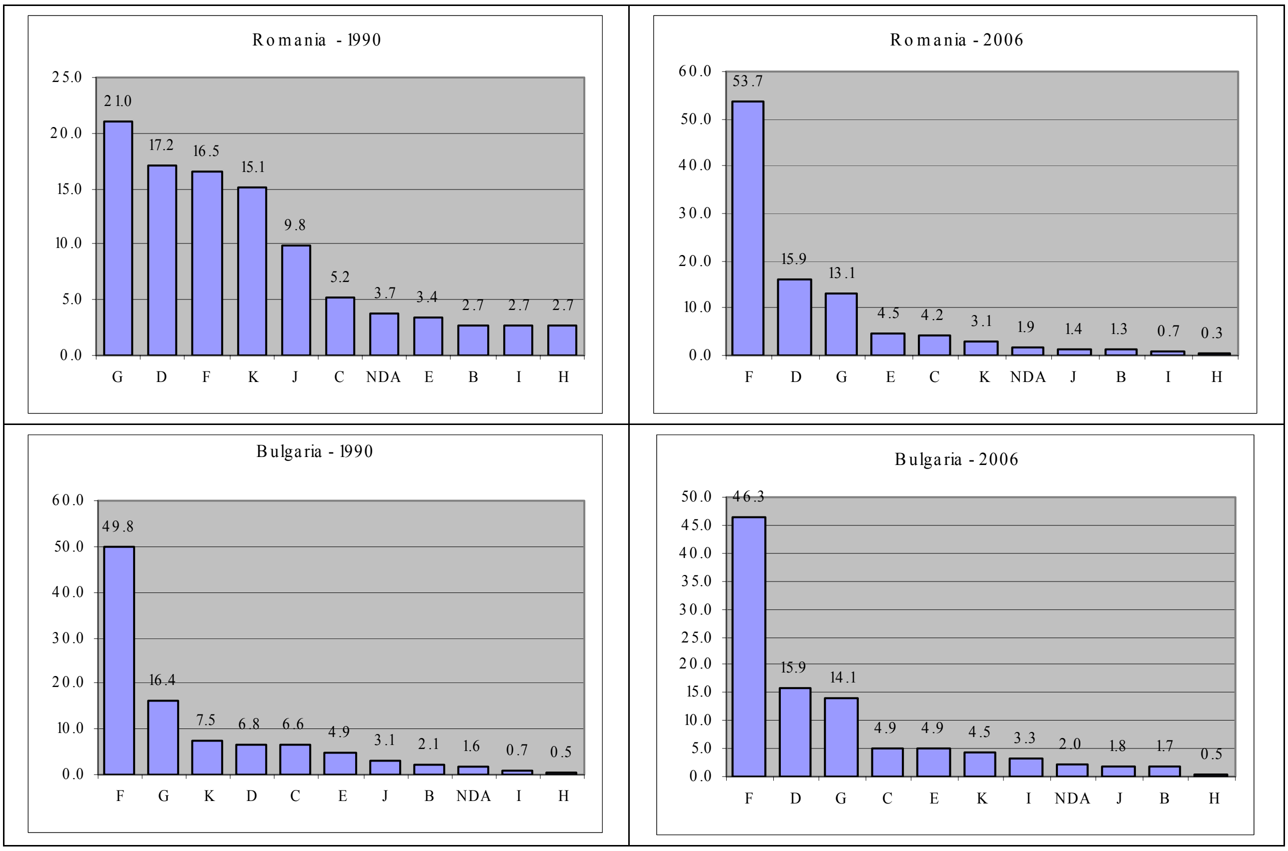
Source: Our calculations using the CHELEM – CEPII database

Figure 2: Exports of Romania and Bulgaria by sector (in %)



Source: Our calculations using the CHELEM – CEPII database

Figure 3: Imports of Romania and Bulgaria by sector (in %)



Source: Our calculations using the CHELEM – CEPII database

Table 1: Country and sector codes

No	Country		No	Sector	
	Code	Name		Code	Products
1	AUT	Austria	1	B	Building materials
2	DEU	Germany	2	C	Iron and steel industry
3	DNK	Denmark	3	D	Textiles, leathers
4	ESP	Spain	4	E	Woods and paper
5	FIN	Finland	5	F	Electric and mechanics
6	FRA	France	6	G	Chemicals
7	GBR	United Kingdom	7	H	Minerals
8	GRC	Greece	8	I	Energy
9	IRL	Ireland	9	J	Agriculture
10	ITA	Italy	10	K	Food
11	NDL	Netherlands	11	NDA	N.D.A.
12	PRT	Portugal			
13	SWE	Sweden			
14	UEBL	Belgium- Luxembourg			

Table 2: Revealed comparative advantages (Lafay indicator – 2 digit level)

	Romania					Bulgaria				
Sector	1990	1995	2000	2004	2006	1990	1995	2000	2004	2006
B	0.07	0.43	0.11	-0.47	-0.74	-0.20	-0.06	-0.31	-0.54	-0.77
C	0.34	4.75	3.23	3.10	1.43	1.14	12.42	14.68	17.81	26.48
D	1.20	4.60	10.28	19.71	24.63	1.63	4.11	6.48	14.67	18.80
E	1.80	1.55	2.20	4.90	5.29	0.06	-1.91	-1.80	0.27	-0.35
F	-0.78	-7.65	-11.72	-19.55	-21.88	-6.56	-15.52	-14.44	-27.09	-39.16
G	-1.70	-1.55	-3.80	-8.27	-9.35	-0.79	-0.77	-4.43	-9.02	-12.62
H	-0.27	0.00	0.66	0.64	1.22	0.29	1.28	1.06	2.29	4.64
I	2.03	-0.29	-0.51	1.97	1.65	1.23	0.07	0.30	1.79	1.96
J	-0.81	0.20	1.18	1.63	1.66	1.94	1.04	0.37	2.69	4.60
K	-1.50	-1.49	-0.86	-2.05	-2.67	1.13	-0.55	-0.88	-0.81	-2.02
NDA	-0.39	-0.56	-0.77	-1.61	-1.24	0.11	-0.12	-1.02	-2.06	-1.56

Source: Our calculations using the CHELEM – CEPII database

Table 3 (a): Grubel-Lloyd indicator for the main sectors (2-digit level)

	Romania					Bulgaria				
Sector	1990	1995	2000	2004	2006	1990	1995	2000	2004	2006
B	0.84	0.73	1.00	0.69	0.48	0.41	0.88	0.73	0.67	0.70
C	0.71	0.25	0.46	0.74	0.91	0.94	0.20	0.23	0.38	0.42
D	0.99	0.99	0.97	0.89	0.80	1.00	0.99	0.98	0.94	0.83
E	0.26	0.78	0.77	0.74	0.88	0.76	0.62	0.69	0.89	0.85
F	0.81	0.44	0.59	0.63	0.59	0.25	0.35	0.48	0.47	0.48
G	0.48	0.65	0.46	0.42	0.39	0.60	0.88	0.65	0.46	0.44
H	0.16	0.93	0.53	0.51	0.46	0.59	0.33	0.51	0.26	0.28
I	0.20	0.73	0.43	0.35	0.69	0.27	0.95	0.94	0.79	0.95
J	0.43	0.82	0.59	0.69	0.87	0.55	0.79	0.93	0.70	0.63
K	0.18	0.29	0.42	0.35	0.27	0.97	0.79	0.79	0.78	0.69
NDA	0.11	0.40	0.32	0.19	0.44	0.90	0.82	0.48	0.32	0.53

Source: Our calculations using the CHELEM – CEPII database

Table 3(b) : Grubel-Lloyd indicator with the main partners (2-digit level)

Country	Romania					Bulgaria				
	1990	1995	2000	2004	2006	1990	1995	2000	2004	2006
AUT	0.67	0.71	0.77	0.71	0.57	0.53	0.56	0.48	0.60	0.68
DEU	0.96	0.88	0.89	0.81	0.73	0.63	0.72	0.78	0.74	0.76
DNK	0.43	0.43	0.72	0.63	0.56	0.42	0.76	0.81	0.69	0.61
ESP	0.49	0.80	0.87	0.97	0.87	0.67	0.39	0.91	0.87	0.75
FIN	0.64	0.72	0.55	0.99	0.61	0.98	0.46	0.50	0.76	0.99
FRA	0.85	0.93	1.00	0.94	0.86	0.79	0.96	0.92	1.00	0.89
GBR	0.73	0.85	0.87	0.90	0.90	0.74	0.94	0.86	0.93	0.89
GRC	0.95	0.80	0.84	0.90	0.88	0.70	0.99	0.89	0.70	0.81
ITA	0.57	0.99	0.95	0.94	0.84	0.69	0.97	0.93	0.98	0.87
NDL	0.94	0.94	0.84	0.77	0.55	0.63	1.00	0.74	0.53	0.57
PRT	0.98	0.60	0.65	0.89	0.48	0.81	0.48	0.99	0.67	0.51
SWE	0.97	0.72	0.82	0.62	0.59	0.58	0.49	0.63	0.62	0.57
UEBL	0.76	0.97	0.97	0.99	0.69	0.65	0.94	0.41	0.58	0.53

Source: Our calculations using the CHELEM – CEPII database

Table 4 (a): Trade flows between EEC-2 and EU-15 by partner (2-digit level)

1990-2006	Romania				Bulgaria			
	IIT	HIIT	VIIT	IT	IIT	HIIT	VIIT	IT
AUT	0.57	0.04	0.53	0.43	0.71	0.04	0.67	0.29
DEU	0.71	0.22	0.48	0.29	0.78	0.20	0.58	0.22
DNK	0.59	0.00	0.59	0.41	0.63	0.00	0.63	0.37
ESP	0.82	0.03	0.79	0.18	0.76	0.04	0.72	0.24
FIN	0.55	0.00	0.55	0.45	0.98	0.01	0.97	0.02
FRA	0.82	0.09	0.73	0.18	0.96	0.08	0.88	0.04
GBR	0.86	0.05	0.81	0.14	0.90	0.04	0.86	0.10
GRC	0.86	0.03	0.84	0.14	0.79	0.11	0.68	0.21
IRL	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
ITA	0.81	0.22	0.59	0.19	0.89	0.19	0.70	0.11
NDL	0.51	0.02	0.49	0.49	0.55	0.02	0.53	0.45
PRT	0.45	0.00	0.45	0.55	0.42	0.00	0.41	0.58
SWE	0.54	0.01	0.53	0.46	0.59	0.01	0.58	0.41
UEBL	0.69	0.02	0.66	0.31	0.48	0.04	0.44	0.52

Source: Our calculations using the CHELEM – CEPII database

Table 4 (b): Trade flows between EEC-2 and EU-15 by sector (2-digit level)

	Romania				Bulgaria			
1990-1999	**IIT**	**HIIT**	**VIIT**	**IT**	**IIT**	**HIIT**	**VIIT**	**IT**
B	0.86	0.16	0.70	0.14	0.77	0.25	0.52	0.23
C	0.35	0.12	0.23	0.65	0.73	0.14	0.59	0.27
D	0.86	0.09	0.77	0.14	0.70	0.07	0.63	0.30
E	0.74	0.09	0.65	0.26	0.55	0.08	0.47	0.45
F	0.55	0.02	0.53	0.45	0.29	0.01	0.28	0.71
G	0.37	0.03	0.35	0.63	0.51	0.02	0.49	0.49
H	0.03	0.01	0.02	0.97	0.56	0.04	0.52	0.44
I	0.11	0.00	0.11	0.89	0.44	0.04	0.40	0.56
J	0.29	0.10	0.19	0.71	0.92	0.05	0.87	0.08
K	0.41	0.02	0.39	0.59	0.69	0.03	0.66	0.31
2000-2006								
B	0.21	0.07	0.14	0.79	0.62	0.54	0.08	0.38
C	0.60	0.20	0.40	0.40	0.67	0.18	0.50	0.33
D	0.75	0.10	0.65	0.25	0.80	0.11	0.69	0.20
E	0.94	0.10	0.83	0.06	0.76	0.10	0.66	0.24
F	0.59	0.02	0.57	0.41	0.36	0.01	0.35	0.64
G	0.37	0.04	0.33	0.63	0.23	0.02	0.21	0.77
H	0.48	0.00	0.48	0.52	0.44	0.15	0.30	0.56
I	0.39	0.06	0.33	0.61	0.60	0.04	0.55	0.40
J	0.97	0.19	0.78	0.03	0.57	0.15	0.41	0.43
K	0.23	0.03	0.21	0.77	0.55	0.05	0.50	0.45
1990-2006								
B	0.36	0.12	0.24	0.64	0.67	0.22	0.45	0.33
C	0.86	0.29	0.57	0.14	0.60	0.17	0.44	0.40
D	0.81	0.10	0.71	0.19	0.76	0.09	0.67	0.24
E	0.99	0.10	0.89	0.01	0.71	0.10	0.61	0.29
F	0.58	0.02	0.56	0.42	0.32	0.01	0.30	0.68
G	0.38	0.04	0.35	0.62	0.32	0.03	0.29	0.68
H	0.25	0.01	0.24	0.75	0.43	0.14	0.29	0.57
I	0.45	0.00	0.45	0.55	0.66	0.05	0.62	0.34
J	0.70	0.23	0.47	0.30	0.69	0.19	0.50	0.31
K	0.31	0.03	0.28	0.69	0.48	0.05	0.43	0.52

Source: Our calculations using the CHELEM – CEPII database

Table 5: Exports, imports and trade balance for Romania and Bulgaria vis-à-vis the EU-15 (2006, million dollars)

Code	Sector	Romania			Bulgaria		
		Export	Import	Balance	Export	Import	Balance
Total	Total	17577.4	27371.8	-9794.4	7279.9	9349.4	-2069.5
B	Building materials	110.4	346.0	-235.6	87.4	163.1	-75.7
C	Iron and steel industry	949.0	1141.2	-192.2	1713.9	460.1	1253.7
D	Textiles, leathers	6522.0	4344.5	2177.6	2121.4	1488.5	632.8
E	Woods and paper	1598.9	1241.4	357.4	337.5	456.1	-118.6
F	Electric and mechanics	6118.5	14690.0	-8571.4	1369.0	4332.9	-2963.9
G	Chemicals	893.7	3599.0	-2705.3	381.9	1320.1	-938.1
H	Minerals	229.3	68.4	160.9	272.2	44.5	227.7
I	Energy	376.8	196.9	179.8	339.8	307.8	32.0
J	Agriculture	495.9	379.5	116.4	367.1	169.3	197.8
K	Food	138.2	846.3	-708.1	221.8	417.4	-195.5
NDA	N.D.A.	144.7	518.6	-373.9	68.0	189.7	-121.6

Source: Our calculations using the CHELEM – CEPII database

Table 6a: Estimated trade flows between EEC-2 and EU-15 over the whole sample and two subperiods using static panel data methods

Variables	1990 - 2006			1990 - 1999			2000 - 2006		
	FEM	REM	FEVD	FEM	REM	FEVD	FEM	REM	FEVD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	x_{ij}	x_{ij}	x_{ij}	x_{ij}	x_{ij}	x_{ij}	x_{ij}	x_{ij}	x_{ij}
GDP_{it}	1.432	1.444	1.432	2.215	0.849	2.215	1.868	2.013	1.868
	(11.13)***	(18.82)***	(11.88)***	(9.21)***	(8.50)***	(9.77)***	(7.17)***	(21.26)***	(20.32)***
GDP_{jt}	2.637	1.628	2.637	2.722	0.841	2.722	3.621	2.045	3.621
	(20.50)***	(21.22)***	(21.74)***	(11.32)***	(8.41)***	(11.92)***	(12.64)***	(21.59)***	(39.77)***
$Dist_{ij}$	0.000	-2.144	-2.143	0.000	-2.050	-2.014	0.000	-2.263	-2.311
	(.)	(9.07)***	(59.22)	(.)	(8.63)***	(32.13)***	(.)	(7.66)***	(38.28)***
$DGDPT_{ijt}$	0.023	0.022	0.023	0.114	0.326	0.114	-0.085	0.003	-0.085
	(1.84)*	(0.59)	(2.11)*	(1.81)*	(4.79)***	(1.72)*	(2.03)*	(3.11)***	(1.95)*
RCS_{ijt}	-0.821	0.006	-0.821	-3.248	-1.070	-3.248	0.120	0.964	0.120
	(3.55)***	(0.05)	(44.50)***	(14.54)***	(7.80)***	(80.20)***	(5.42)***	(6.21)***	(12.58)***
Acc_{ijt}	0.255	0.336	0.255	-	-	-	-	-	-
	(13.51)***	(21.63)***	(7.86)***						
Residuals	-	-	1.000	-	-	1.000	-	-	0.923
			(142.10)***			(199.87)***			(288.77)***
Constant	-19.827	-7.497	-12.946	-26.202	-2.362	-19.736	-23.194	-11.277	-18.866
	(22.42)***	(7.76)***	(123.84)***	(12.35)***	(2.02)**	(152.13)***	(14.14)***	(9.46)***	(282.21)***
Observations	952	952	952	560	560	560	392	392	392
Number of groups	56	56	-	56	56	-	56	56	-
R-squared	0.72	0.73	0.95	0.42	0.78	0.95	0.76	0.70	0.99
Fischer	48.74	-	-	28.36	-	-	90.70	-	-
Prob>F	(0.00)			(0.00)			(0.00)		
Hausman	-	892.13	-	-	173.33	-	-	466.84	-
Prob>chi2		(0.00)			(0.00)			(0.00)	
Absolute value of t statistics in parentheses									
* significant at 10%; ** significant at 5%; *** significant at 1%									

Table 6b: Estimated trade flows between EEC-2 and EU-15 over the whole sample and two subperiods using the GMM dynamic panel data method

Variable	1990-2006	1990-1999	2000-2006
	(1)	(2)	(3)
	x_{ij}	x_{ij}	x_{ij}
LX_{ij-1}	0.853	0.696	0.881
	(101.57)***	(39.17)***	(28.47)***
GDP_{it}	0.307	0.317	0.397
	(9.21)***	(9.15)***	(7.04)***
GDP_{jt}	0.304	0.291	0.364
	(8.14)***	(8.64)***	(3.42)***
$Dist_{ij}$	-0.304	-0.658	-0.268
	(3.40)***	(12.49)***	(3.88)***
$DGDPT_{ijt}$	0.018	0.031	-0.010
	(3.00)***	(1.97)*	(3.33)***
RCS_{ijt}	-0.079	-0.298	0.241
	(2.67)***	(7.37)***	(5.63)***
Acc_{ijt}	0.061	0.084	-
	(17.12)***	(17.17)***	
Constant	-2.040	-0.816	-2.633
	(4.77)***	(3.03)***	(6.00)***
Observations	952	560	392
Number of cod_rel	56	56	56
Hansen test of overidentification	55.24	53.36	53.86
Prob > chi2	(1.00)***	(0.95)***	(1.00)***
Arellano-Bond test for AR(2)	0.60	0.66	-0.69
Prob > z	(0.55)***	(0.51)***	(0.49)***
Absolute value of t statistics in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

Table 7: Estimated impact of intermediate goods on the exports of EEC-2 to EU-15

Variable	**FEM**	**REM**	**FEVD**	**GMM**
	(1)	**(2)**	**(3)**	**(4)**
	x_{ij}	**x_{ij}**	**x_{ij}**	**x_{ij}**
$L.x_{ij}$	-	-	-	0.685
				(10.09)***
GDP_{it}	1.884	0.913	1.884	0.371
	(8.65)***	(5.31)***	(9.01)***	(1.90)*
GDP_{jt}	1.776	1.351	1.776	0.272
	(8.56)***	(8.34)***	(8.75)***	(2.30)**
$Dist_{ij}$	0.000	-1.637	-1.675	-1.168
	(.)	(7.62)***	(38.53)***	(2.03)*
$DGDPT_{ijt}$	0.006	0.026	0.006	0.143
	(0.13)	(0.56)	(0.02)	(2.41)**
RCS_{ijt}	-1.261	0.108	-1.261	-0.409
	(3.98)***	(0.43)	(46.49)***	(1.83)*
$Mint_{ijt}$	0.200	0.210	0.200	0.125
	(7.06)***	(7.50)***	(8.08)***	(9.12)***
Acc_{ijt}	0.174	0.269	0.174	0.061
	(6.94)***	(12.21)***	(4.56)***	(4.32)***
Residuals	-	-	1.000	-
			(101.91)***	
Constant	-18.289	-5.305	-12.912	0.000
	(15.07)***	(5.27)***	(105.58)***	(.)
Observations	476	476	476	476
Number of groups	28	28	-	28
R-squared	0.82	0.85	0.96	-
Fischer	31.34	-	-	-
Prob>F	(0.00)			
Hausman	-	33.67	-	-
Prob>chi2		(0.00)		
Hansen test of overidentification	-	-	-	26.49
Prob > chi2				(1.00)***
Arellano-Bond test for AR(2)	-	-	-	-0.28
Prob > z				(0.78)***
Absolute value of t statistics in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

APPENDIX

1. Fixed effect vector decomposition (FEVD)

Fixed effect vector decomposition (FEVD) is a three-stage method proposed by Plümper and Troeger (2004) as an alternative to the model of Hsiao (2003). It allows the inclusion of time-invariant variables and efficient estimation of their parameters within a panel fixed effects framework.

A general form of the regression equation in the case when the right-hand side variables include time-invariant variables is the following:

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{itk} + \sum_{j=1}^{J} \gamma_j z_{ij} + u_i + \varepsilon_{it} \quad \text{(i = 1,2 … N) individuals} \quad (1)$$

where :

x_{itk} = k=1,2……K time-variant variables;

z_{ij} = j=1,2……J time-invariant variables;

u_i = individual effects fixed over time;

ε_{it} = normal distributed error component;

In brief, FEVD involves the following three steps:

- ► I) estimation of (1) by the Fixed Effects Model (FEM) to obtain the unit-fixed effects;
- ► II) regression of the unit-fixed effect vector obtained in step 1 on the right-hand side time-invariant variables of the original model (by Ordinary Least Squares, OLS);
- ► III) re-estimation of the original model by pooled OLS (or Prais-Winston in the presence of serial correlation), by including all time-invariant explanatory variables and the unexplained part of the unit-fixed effect vector[6]. The third stage is required to control for multi-collinearity and to adjust the degrees of freedom.[7]

[6] In a second stage, the unit fixed effects vector resulting from the first stage are decomposed into a part explained by the time-invariant variables and an unexplained one (the error term).

[7] The STATA programme we use (ado-file) executes all three steps and adjusts the variance-covariance matrix. Options like AR (1) error-correction and robust variance-covariance matrix are allowed.

More in detail, the procedure is the following:

I) If we substract from (1) the average over time of (1) we obtain the fixed effects transformation as:

$$
\begin{aligned}
y_{it} - \bar{y}_i &= \beta_k \sum_{k=1}^{K} (x_{kit} - \bar{x}_{ki}) + \sum_{j=1}^{J} (z_{ij} - z_{ij}) + (u_i - u_i) + \varepsilon_{it} - \bar{\varepsilon}_i \equiv \tilde{y}_{it} = \\
&= \beta_k \sum_{k=1}^{K} (x_{kit} - \bar{x}_{ki}) + \varepsilon_{it} - \bar{\varepsilon}_i \equiv \beta_k \sum_{k=1}^{K} \tilde{x}_{ki} + \tilde{\varepsilon}_{it}
\end{aligned} \quad (2)
$$

Here the unobserved effect, u_i, disappears and it may lead to unbiased and consistent results. The unit effects are explained by:

$$\hat{u}_i = \bar{y}_i - \sum_{k=1}^{K} \hat{\beta}_k^{FEM} \bar{x}_{ki} - \bar{\varepsilon}_i \quad (3)$$

II) The second step implies the regression of $\hat{u}_i$ obtained in (3) on the z-variables.

$$\hat{u}_i = \omega + \gamma_j \sum_{j=1}^{J} z_{ji} + \eta_i \quad (4)$$

where ω is the intercept of the stage-2 equation and η_i is the unexplained part of the unit effects. The estimates are unbiased only if $\eta_i \cong 0$ for all *i* or if $E(z_i \mid \eta_i) = E(z_i) = 0$.

III) The full model is rerun by including the $\hat{\eta}_i$ obtained in step 2 (by predicting equation (4) without unit effects. In the third step the following equation is estimated by pooled OLS (or Prais-Winston in the presence of serial correlation):

$$y_{it} = \alpha + \beta_k \sum_{k=1}^{K} x_{kit} + \gamma_j \sum_{j=1}^{J} z_{ji} + \hat{\eta}_i + \varepsilon_{it} \quad (5)$$

By construction, $\hat{\eta}_i$ is no longer correlated with the vector of the z's and its coefficient is either equal to 1.0 or at least close to 1.0 Estimating stage 3 by pooled OLS further requires that heteroscedasticity and serial correlation should be eliminated beforehand.

At least in theory this method has three obvious advantages:[8] a) it does not require prior knowledge of the correlation between unit specific effects and time-variant explanatory

[8] See Plümper and Troeger (2004).

variables; b) it does not require the orthogonality assumptions (for time-variant variables) for the random effects to be satisfied; c) it is as efficient estimator like OLS.

Essentially the main advantages of FEVD come from the lack of bias in estimating the coefficients of time-variant variables that are correlated with unit-effects.

2. The Generalized Moment Method (GMM) for dynamic panels

A dynamic model is a model in which one or more lags of the dependent variable appear as explanatory variables. We consider the following equation:

$$y_{i,t} = \alpha y_{i,t-1} + \beta X_{i,t} + u_i + v_t + e_{i,t} \qquad (1)$$

where X_{it} represents the explanatory variables of the model, u_i is the individual specific effect, v_t is the time specific effect, and e_{it} is the error term (***i*** is individual index, and ***t*** is the time index).

The presence of the lagged dependent variable as explanatory variable does not allow the use of standard econometric techniques. The GMM method for dynamic panels provide solutions to the problems of simultaneity bias, reverse causality and omitted variables. Besides, it allows to control for individual specific effects u_i, and time effects v_t, as well as to overcome endogeneity bias.

There are two types of GMM estimators for dynamic panels:

- The first-differenced GMM estimator (Arellano and Bond -1991);
- The GMM system estimator (Blundell and Bond - 1998).

The first-differenced GMM estimator eliminates specific individual effects through first-differencing of a single equation, and then instruments the explanatory variables using their lagged values in levels. The GMM system estimator involves the estimation of a system containing both first–differenced and levels equations, where the variables are instrumented by their first differences.

The choice of lagged variables as instruments depends on the nature of the explanatory variables:

1. For the exogenous variables, their current values are used as instruments;

2. For variables which are either predetermined or influenced by previous values of the dependent variable, but not correlated with future values of the error term, lagged (at least one period) values can be used as instruments;
3. For endogenous variables, only their lagged (at least two periods) values can be used as valid instruments.

The use of these estimators is based on the assumption of quasi-stationary variables in the equation in levels, and no autocorrelation of the residuals. To deal with potential omitted variables bias arising from specific effects, the strategy of Arellano-Bond estimator (1991) is to take first differences. This implies the following specification:

$$y_{i,t} - y_{i,t-1} = \alpha(y_{i,t-1} - y_{i,t-2}) + \beta(X_{i,t} - X_{i,t-1}) + (v_t - v_{t-1}) + (e_{i,t} - e_{i,t-1}) \quad (2)$$

By construction, the error term $(e_{i,t} - e_{i,t-1})$ is correlated with the lagged variable in differences $(y_{i,t-1} - y_{,t-2})$. The first differences of the explanatory variables of the model are instrumented through their lagged values (in levels) in order to reduce the simultaneity bias and the bias resulting from the presence of the lagged dependent variable in differences on the left-hand side.

Under the assumption that the error terms are not autocorrelated and that the explanatory variables of the model may be influenced by lagged values, but are uncorrelated with future values of the error term, the following moment conditions have to be satisfied for the equation in first differences:

$$E|(y_{i,t-s}, (e_{i,t} - e_{i,t-1})| = 0 \text{ for } s \geq 2 \text{ ; } t = 3,\ldots,T \quad (3)$$

$$E|(X_{i,t-s}, (e_{i,t} - e_{i,t-1})| = 0 \text{ for } s \geq 2 \text{ ; } t = 3,\ldots,T \quad (4)$$

But, this estimator suffers from the "weakness" of its instruments, which entails considerable bias, especially for small size samples, and therefore its accuracy is asymptotically low. Specifically, the lagged values of the explanatory variables are "weak" instruments for the equation in first differences: the GMM estimator for the first difference takes into account only the intra- individuals variations, the inter-individuals variations being removed through differentiation.

The GMM system estimator eliminates this problem by combining the equation in difference with an equation in levels, i.e. it estimates equation (2) (in first differences) simultaneously with equation (1) (in levels). In equation (1), the variables are instrumented using their most recent lags in first differences. Blundell and Bond (1998) tested this method using Monte Carlo simulations and found that:

- the GMM system estimator is more efficient than the GMM in difference.
- the GMM in first difference produces biased coefficients for small samples when the instruments are "weak".

For the equation in levels, the GMM system method uses additional moment conditions assuming that the explanatory variables are stationary:

$$E|(y_{i,\,t-s} - y_{i,t-s-1}) \,.\, (u_i + e_{i,t})| = 0 \text{ for } s = 1 \qquad (5)$$

$$E|(X_{i,\,t-s} - X_{i,t-s-1}) \,.\, (u_i + e_{i,t})| = 0 \text{ for } s = 1 \qquad (6)$$

Conditions 3 to 6 combined with the GMM method allow one to estimate the coefficients of the model.

To test the validity of the lagged variables as instruments, Arellano and Bond (1991) and Arellano and Bover (1998) suggest the Sargan/Hansen test of over-identification. By construction the error term in first differences is autocorrelated of order one, but it should not be autocorrelated of order two. To test this hypothesis, Arellano and Bond (1991) recommend using an (AR2) autocorrelation test, where the null hypothesis is the absence of second-order autocorrelation in the residuals of the equation in differences.