Modeling International Trade Flows between CEEC and OECD Countries

CHRISTOPHE RAULT
ROBERT SOVA
ANA MARIA SOVA

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Abstract

This article deals with econometric developments for the estimation of gravity model, which allow to get convergent parameter estimates even when a correlation exists between the explanatory variables and the specific unobservable characteristics of each individual. We implement panel data econometric techniques to characterize bilateral trade flows between heterogeneous economies. Our econometric results based on a sample of 4 Central and Eastern European countries (CEEC-4) and 19 OECD countries over a 18-year period highlight the importance by taking into account the unobservable heterogeneity to obtain a robust empirical specification and unbiased coefficients.

JEL Code: F13, F15, C23.

Keywords: gravity models, unobservable heterogeneity, panel data models, international trade flows.

Christophe Rault
University of Orléans
LEO, CNRS, UMR 6221
Rue de Blois-B.P. 6739
45067 Orléans Cedex 2
France
chrault@hotmail.com

Robert Sova
Sorbonne University Paris I
E.B.R.C. and A.S.E
106-112 bd. de L'Hôpital
75647 Paris Cedex 13
France
robertsova@yahoo.com

Ana Maria Sova
Sorbonne University Paris I
E.B.R.C. and A.S.E
106-112 bd. de L'Hôpital
75647 Paris Cedex 13
France
anamariasova@yahoo.fr

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1. Introduction

The aim of this article is to examine and characterize trade relationships between a set of developing and developed countries using recent advances in the econometrics of panel data techniques with fixed effects, which permit to take the unobserved heterogeneity of country behaviour over time into account. Our database includes 4 Central and Eastern European countries[4] (CEEC-4) and 19 OECD countries[5] (including the European Union, EU-15)[6]. In our mind this set of heterogeneous economies constitutes a relevant and interesting framework worth being analysed.

First of all, we propose an evaluation of the type of trade and of the specialization degree of economies. In particular, we are interested in determining whether CEEC countries continued to specialize in labour intensive industries with their comparative advantage of less expensive labour costs and hence, have developed an inter-industry trade, or on the contrary, have generated an intra-industry trade related to an economic convergence. CEEC countries aim at reducing their economic development gap and to intensify the convergence process between these two groups of economies[7] and hence, the competition in the area.

The various theories of international trade permit to release those which are the most relevant in the analysis of trade flows between CEEC and OECD[8] countries. Our approach is based on the gravity equation, which is suitable to the analysis of intra-industry trade as well adapted as to the analysis of inter-industry trade. More precisely, it allows to characterize the type of trade and hence, the specialization in a certain moment.

4 Hungary, Poland, Bulgaria and Romania, which became new member states of the European Union on May 2004 and January 2007.
5 EU-15: Austria, Belgium-Luxemburg, Denmark, England, Finland, France, Germany, Greece, Holland, Ireland, Italy, Portugal, Spain, Sweden; nonEU countries: Australia, Canada, Japan, Switzerland, the United States of America.
6 Moreover, CEEC countries exchange with the EU-15 countries almost 70% of the total trade.
7 CEEC and OECD countries.
8 Organization for Economic Cooperation and Development.

In international trade, the gravity model is widely used as a basic model for estimating the effect of regional agreements, the effect of the monetary union on trade flows and to simulate the trade potential[9].

From an econometric point of view, the choice of the econometric methodology is in accordance with the recent developments of panel data methods, which explicitly take unobserved heterogeneity into account. In fact, the standard crosssection estimates tend to ignore the unobservable characteristics of bilateral trade relationships (historical, cultural and linguistic links). The existence of a potential correlation between the unobservable characteristics and a subset of the explanatory variables run the risk of obtaining biased estimates (cf. Baltagi, 2001). A possible method to eliminate this correlation consists in using the within estimator. In transforming the data into deviations from individuals means, the within estimator provides unbiased and consistent estimates. However, all time invariant variables are eliminated by the data transformation. To overcome this problem, Hausman and Taylor (1981) propose an instrumental variable estimator for panel data regression.

The remainder of this article is organized as follows. Section II presents an overview of the theoretical foundations of the gravity model. Section III exposes our panel data methodology. Section IV reports the empirical investigation as well as our econometric results and finally Section V discusses the policy implications and concludes.

2. Theoretical Foundations of the Gravity Model

Inspired initially by the law of physics (Newton), the gravity model has become an essential tool in the simulations of international trade flows. The first applications were rather intuitive without substantial theoretical claims. These applications were the object of critics concerning the lack of robust theoretical foundations. Among the first studies which

9 See, for instance Bayoumi and Eichengreen (1997), Frankel (1997), Matyas (1997), Wei and Frankel (1998), Rose (2000), Soloaga and Winters (2001), Ghosh and Yamarick (2004), Baier and Bergstrand (2005), Cheng and Wall (2005), Carrère (2006), Rault and Sova (2007).

have used the gravity model in economic analysis, can note those by Beckerman (1956), Tinbergen (1962), Poyhonen (1963), Linnemann (1966), and Aitken (1973).

Linnemann explains trade flows between countries ***i*** and ***j*** and then defines it as a combination of three factors: the offer of the exporter country ***i***, the demand of the importer country ***j*** and the resistance of trade between countries ***i*** and ***j***. The potential offer of the exporter is a positive function of the income level of the exporter country which can be interpreted as a proxy of available good varieties. The potential demand of the importer country also depends positively of the income level of the importer country. In other words, the national incomes of two countries ***i*** and ***j***, transport costs (transaction costs) and regional agreements are the basic determinants of the model.

Gravity models have received theoretical foundations due to the development of new international trade theories with imperfect competition. Helpman and Krugman (1985) propose a formalization of the gravity equation, in which the intra-trade and inter-trade approaches are reconciled.

Bergstrand (1989) model represents an extension of Helpman and Krugman model, taking into account the offer and the demand functions in explaining trade flows. The model also includes a variable of income per capita representing the capital intensity of the exporter country and of the importer country, reflecting a relative factor endowment in terms of GDP per capita. For this author this variable is an indicator of demand sophistication. The required goods may be either luxury or necessity goods. Bergstrand proposes the most complete version of the gravity model using for instance, variables like GDP, GDP per capita, distance and monetary variables.

The gravity model has been widely used in the applied literature to evaluate the impact of regional agreements, the impact of a monetary union, the impact of Foreign Direct investments (FDI) on trade flows and to simulate the trade potential[10]. After this brief

10 Bayoumi and Eichengreen (1997) note that ‘the gravity equation has long been the workhorse for empirical studies of the pattern of trade’.

overview of the theoretical foundation of the gravity model, we are now interested in finding the appropriate empirical specification of this model to better characterize the trade flows between countries with a different economic development level (heterogeneous economies), more particularly between CEEC and OECD countries. In the next section, we present the econometric methodology, which rests upon panel data techniques.

3. The Econometric Methodology

Most studies estimating a gravity model were carried out on cross-section data[11]. Recently several papers have argued that standard cross-section methods lead to biased results because they do not control for heterogeneous trading relationships. For instance, the impacts of historical, cultural and linguistic link trade flows are difficult to observe and to quantify, the presence of minorities or past memberships in a common trade area can also lead to biased estimates. Panel data regressions allow to correct for such effects. The use of panel data is preferred in our analysis because it allows to control for specific effects (as fixed or random effects). The source of potential endogeneity bias in gravity model estimations is the unobserved individual heterogeneity.

Matyas (1997) argues that cross-section approach is affected by a problem of misspecification and consider that a correct econometric specification of gravity model is a 'three-way model' with exporter, importer and time effects (random or fixed effects). Concerning panel data, Egger (2000) mentions that the most appropriate methodology is for disentangling time-invariant and country-specific effects.

Egger and Pfaffermayr (2003) indicate that the omission of specific effects per country pair can biased the estimated coefficients. An alternative solution is to use an estimator to control for bilateral specific effects like fixed-effects model (FEM) or random-effects model (REM).

11 See Baldwin (1994), Gros and Gonciarz (1996), Wei and Frankel (1998) and Sapir (2001).

However, FEMs allow for unobserved or misspecified factors that simultaneously explain trade volume between two countries and lead to unbiased and efficient results[12].

The choice of the method (FEM or REM) depends on two important things, its economic and econometric relevance. From an economic point of view, there are unobservable time invariant random variables, difficult to be quantified, which may simultaneously influence some explanatory variables and the trade volume. From an econometric point of view, the inclusion of fixed effects is preferable to random effects because the rejection of the null assumption of uncorrelation of the unobservable characteristics with some explanatory variables is less plausible (Baier and Bergstrand, 2005).

We now briefly present the panel data econometric methods13 used in our article to estimate the possible various specifications of our models: pooled ordinary least squares (POLS), random effect estimator (REM), within estimator (FEM) instrumental variables Hausman–Taylor estimator (HT).

3.1 Pooled Ordinary Least Square (POLS)

The class of models that can be estimated using a pooled ordinary least squares estimator can be written as follows

$$y_{it} = \beta x_{it}^{'} + \alpha z_i^{'} + \varepsilon_{it} \qquad i = 1,2, \ldots, N, \; t = 1,2, \ldots, T \qquad (1)$$

, where y_{it} is the dependent variable, x_{it} are K regressors not including a constant term. The heterogeneity or individual effect is $\alpha z_i^{'}$ where z_i contains a constant term and a set of

12 See for instance, Festoc (1997), Matyas (1997), Rose (2000), Glick and Rose (2002), Egger (2002), Ghosh-Yamarick (2004), Baier and Bergstrand (2005), Cheng and Wall (2005), Carre` re (2006) and Peridy (2006).
13 See Wooldridge (2002, 2005) and Hausman-Taylor (1981).

individual or group specific variables, which may be observed or unobserved, all of which are taken to be constant over time t.

Ordinary Least Squares (OLS) is often used to estimate the gravity model but does not permit to control the individual heterogeneity and hence may yield to biased results due to a correlation between some explanatory variables and some unobservable characteristics. If the Breusch Pagan LM test rejects the null hypothesis in favor of random effects, the OLS method is not adequate.

3.2 Within estimator and random estimator (FEM and REM)

In the presence of correlation of the unobserved characteristics with some explanatory variables random effect estimator leads to biased and inconsistent parameter estimates. For eliminating this correlation it is possible to use a traditional method called "within estimator or fixed effects estimator" which consists in transforming the data into deviations from individual means. In this case, even if a correlation between unobserved characteristics and some explanatory variables exists, the within estimator may provide unbiased and consistent results.

The fixed effects model can be written as

$$y_{it} = \sum_{k=1}^{K} \beta_k x_{k\,it} + \alpha_i + u_{it} \text{, t = 1, 2,…,T; k=1, 2,..,K regressors; i=1, 2,.,N individuals} \qquad (2)$$

, where α_i denotes individual effects fixed over time and u_{it} is the disturbance terms.
If we subtract from (2) the average over time of (2) we obtain the fixed effects transformation as:

$$y_{it} - \bar{y}_i = \sum_{k=1}^{K} \beta_k (x_{k\,it} - \bar{x}_{ki}) + (u_{it} - \bar{u}_i) \qquad (3)$$

In the fixed effects transformation, the unobserved effect, α_i, disappears because it is fixed over time. A pooled OLS estimator based on equation (3), called fixed effects estimator or within estimator, may lead to unbiased and consistent results.

The random model has the same form as in (2),

$$Y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} \ldots\ldots\ldots\ldots\ldots + \beta_k x_{itk} + \alpha_i + u_{it} \qquad (4)$$

, where an intercept is included so one can make the assumption that the unobserved effect, α_i, has zero mean (without loss of generality), see Wooldridge (2005).

Equation (4) becomes a random effect model when we assume that the unobserved effect α_i is uncorrelated with each explanatory variable:

$$\mathrm{Cov}(x_{itk}, \alpha_i) = 0, \quad t = 1,2,\ldots, T;\ j = 1,2,\ldots, k.$$

The hypothesis mentioned above is actually less plausible and the GLS estimator may lead to biased results.

The Hausman (chi^2) test consists in testing the null hypothesis of no correlation between unobserved characteristics and some explanatory variables and allows us to make a choice between random estimator and within estimator. The within estimator has however two important limits:

- it may not estimate the time invariant variables that are eliminated by the data transformation;
- fixed effects estimator ignores variations across individuals. The individual's specificities can be correlated or not with the explanatory variable. In traditional methods these correlated variables are replaced with instrumental variables uncorrelated to unobservable characteristics.

3.3 Hausman Taylor method (HT)

Hausman Taylor (1981) estimator (hereafter HT) overcomes this problem using a method which allows to consider some explanatory variables included in the model as instruments. In this case the major difficulty of instrumental methods which consists in finding external instruments (not from original specification) and uncorrelated with unobservable characteristics is avoided. The considered equation is as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it}^1 + \beta_2 X_{it}^2 + \Upsilon_1 Z_i^1 + \Upsilon_2 Z_i^2 + \alpha_i + \eta_{it} \quad (5)$$

, with the condition that the explanatory variables are not correlated with η_{it}, even if some of them are correlated with α_i.

Our explanatory variables are divided into four categories: time varying uncorrelated (X^1_{it}), time varying correlated with α_i (X^2_{it}), invariant uncorrelated (Z^1_i) and invariant correlated with α_i (Z^2_i).

The X^2_i regressors are instrumented by the deviation from individual means (as in the Fixed Effect aproach) and the Z^2_i regressors are instrumented by the individual average of X^1_{it} regressors. Hausman Taylor estimator allows us to estimate the effect of time-invariant variables such as distance, common border, common languages etc. Hausman Taylor (HT) estimator doesn't use external instruments.

The variables are divided into two matrices. The X matrix contains k_1 columns of X^1_{it} and k_2 columns X^2_{it} and the Z matrix contains g_1 columns of Z^1_i and g_2 columns of Z^2_i. The variables to be instrumented are X^2_{it} and Z^2_i. The set of instruments proposed by HT is the following one: (QX^1_{it}, QX^2_{it}, PX^1_{it}, Z^1_i), where $k_1 > g_2$. The deviations to the average (Q) are those that eliminate the correlation of the variable X^2_{it}, and the X^1_{it} averages corrects for the Z^2_i variables (with the condition that the number of X^1_{it} uncorrelated variables is larger or at least equal to the number of Z^2_i correlated variables, that is to say $k_1 \geq g_2$). Because of error autocorrelation the estimated coefficients are not efficient even if they are unbiased. For this reason Hausman Taylor use predefined instruments to get unbiased and efficient results. When the model is overidentified ($k_1 > g_2$) these estimators are more efficient than those of the within model. To test for the assumption of no-correlation of the X^1_{it} and Z^1_i variables one can compare the within estimators with those of HT.

4. The Empirical Investigation

We carry out several panel data estimations in order to compare the results across specifications and to identify the most robust one. We first make a test for individual effects and if this confirms their presence, then for controlling the individual effects we carry out an REM and FEM estimate. To eliminate the unobservable heterogeneity due to bilateral specific effects and to avoid the potential bias of the estimators taking into account for the invariant time variables it is advisable to use Hausman Taylor estimator. Hausman test indicates by the value of chi^2 whether the specific effects are correlated or not with the explanatory variables.

The specification retained here to characterize the trade between CEEC and OECD countries can be written as follows:

$$X_{ijt} = e^{a_0} GDP_{it}^{a_1} GDP_{jt}^{a_2} DGDPT_{ijt}^{a_3} Dist_{ij}^{a_4} Tcrh_{ijt}^{a_5} e^{a_6 Acc_{ijt}} e^{a_7 Cl_{ij}} e^{a_8 Cb_{ij}} e^{a_9 D_t} e^{\varepsilon_{ijt}} \qquad (6)$$

where :

- X_{ijt} denotes the bilateral trade between countries ***i*** and ***j*** at time ***t*** with $i \neq j$ (CHELEM – CEPII French data base);
- a_o is the intercept;
- GDP_{it}, GDP_{jt} represents the Gross Domestic Product of country ***i*** and country ***j*** (CHELEM CEPII – data base)
- $DGDPT_{ijt}$ is the difference of GDP per capita between partners and is a proxy of economic distance or of comparative advantage intensity,

$$DGDPT_{ijt} = \left| \frac{GDP_{it}}{POP_i} - \frac{GDP_{jt}}{POP_j} \right| \qquad (7)$$

where $POP_{i(j)}$ is the population (CHELEM CEPII data base);

- $Dist_{ij}$ represents the distance between two countries, (CEPII data base);
- $Tcrh_{ijt}$ is the real exchange rate which indicates the competitiveness of price;

$$Tchr_{ijt} = Tcn_{ijt} \times {P_{it}}/{P_{jt}} \qquad (8)$$

where: Tcn_{ijt} is the real exchange rate (CHELEM CEPII data base)

$P_{i(j)}$ is consumer price index (WORLD BANK – World Tables)

- Acc_{ijt} is a dummy variable that equals 1 if country ***i*** and country ***j*** have signed a regional agreement, and zero otherwise,
- Cl_{ij} is a dummy variable that equals 1 if country ***i*** and country ***j*** are membership to a International Organization (Francophone International Organization), and zero otherwise,
- Cb_{ij} is a dummy variable which indicates a common border,
- D_t is a time-dummy variable,
- ε_{ijt} is the error term.

After log linearization equation (6) becomes:

$$Ln(X_{ijt}) = a_0 + a_1 ln(GDP_{it}) + a_2 ln(GDP_{jt}) + a_3 ln(DGDPT_{ijt}) + a_4 ln(Dist_{ij}) + a_5 ln(Tchr_{ijt}) + a_6 Acc_{ijt} + a_7 Cl_{ij} + a_8 Cb_{ij} + a_9 D_t + \varepsilon_{ijt} \quad (9)$$

The expected signs for the estimators associated with the variables are based on traditional arguments. Theoretically, we expect a positive effect on trade flows of variables like the country size, the association agreement, the common language, the common border and a negative impact of geographical distance and of real exchange rate. The more the real exchange rate index drops the more there is a depreciation of the exporter currency with respect to the currency of his partner and hence export competitiveness is improved. Concerning the sign of the difference of GDP per capita, it is positive if the Heckscher-Ohlin (H-O) assumptions are confirmed. On the contrary, according to the new trade theory, the income per capita variable between countries is expected to have a negative impact. According to the classical theory, an increase in the intensity of comparative advantages should involve an increase in trade flows. Countries very different in factors endowments and in comparative advantages would exchange more between them. Geographical distance has theoretically always a negative impact being a proxy of transport costs. Our estimates are organized in a panel way with four CEEC and 19 OECD countries, including EU -15 countries which are the main partners for CEEC-4. The data used cover a 18 year period (from 1987 to 2004). The results of FEM, REM and HT estimations are reported in Table 1.

Table 1: The results of FEM, REM, and HT estimations

VARIABLES	Within + time effects	Random effects	Hausman -Taylor
	(1)	(2)	(3)
	X_{ijt}	X_{ijt}	X_{ijt}
ln(GDP_{it})	0.457	0.697	0.457
	(3.78)***	(8.76)***	(3.78)***
ln(GDP_{jt})	0.914	0.977	0.914
	(4.45)***	(16.94)***	(4.44)***
ln($Dist_{ij}$)	-	-1.204	-1.621
	-	(-14.08)	(-2.56)***
ln($DGDPT_{ijt}$)	0.137	0.117	0.137
	(1.96)***	(2.03)**	(1.95)***
ln($Tchr_{ijt}$)	-0.023	-0.062	-0.023
	(-1.20)	(-3.86)***	(-1.20)
Acc_{ijt}	0.161	0.167	0.161
	(8.16)***	(8.49)***	(8.15)***
Lc_{ij}	-	-0.037	1.572
	-	(0.84)	(0.89)
Cb_{ij}	-	0.084	2.206
	-	(0.205	(0.66)
D_t	***	***	***
Constant	-5.679	-3.218	-2.177
	(-4.84)***	(-5.61)***	(-2.39)**
N°. Observations	1368	1368	1368
N°. groups	76	76	76
R-squared	0.71	0.78	-
VIF[14]	0.37	1.33	-
Ramsey-Reset [15] Prob>Chi^2	31.97 (0.0)	2561.08 (0.00)	-
Breusch - Pagan / Cook – Weisberg[16] (before correction) Prob>chi2	24.85 (0.00)	13616.56 (0.00)	-
Hausman test Prob>Chi^2	-	16.68 (0.78)	-
Absolute value of t statistics are in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

[14] VIF test for multicolinearity calculates the variance inflation factors for the independent variables specified in the fitted model.

[15] Ramsey Reset test can be used to test for a multitude of specification problems including omitted variables (see Wooldridge, 2002). It amounts to testing y = xb+zt+u and then testing t=0. If no option is specified, powers of the fitted values are used for z and otherwise powers of the individual elements of x are used.

[16] Breusch Pagan/Cook Weisberg test for heteroskedasticity performs a score test for H: b=0 against multiplicative heteroskedasticity; var(y) = s^2 exp($b_1z_1 + b_2z_2 + ... + b_kz_k$).

In all estimations we can note that the income per capita variable has the expected positive sign which is in accordance with the H-O theory, i.e. trade between two zones is based on comparative advantage. It's a complementary inter-industry trade where less developed countries are specialized in labor intensive industries and where wage costs are less expensive. But, the coefficient is low (0.137) implying that inter-industry trade is reduced in favor of vertical intra-industry trade, which is associated to multinationals strategies of production development on segments of quality. Moreover, an access to a larger market, implies an increase of the trade flows volume (according to coefficient of the size of importer country coefficient). Variables like country size, difference of incomes per capita, which have the most important coefficients explain better the level of bilateral exchanges. The international organization membership has a low influence on trade flows. On the contrary, the distance variable (proxy costs of transport) represents an obstacle for trade. It should be noted that the distance between countries has an important elasticity (-1.621) and hence has an important explanatory capacity.

A comparison between the three estimation leads to the following conclusion. The results of random estimator are different from those obtained with the within estimator, for some explanatory variables. This means that there exists a correlation between some of the explanatory variables and the bilateral specific effect. Moreover, the Hausman test confirms the presence of a correlation and rejects the null assumption of absence of a correlation between the individual effects and explanatory variables. Random estimate is biased, and in this case the use of Hausman-Taylor instrumental variables methods (1981) to correct the bias is justified. Using HT we obtain similar coefficients to FEM and also we highlight the time - invariant variables and their important influence on trade flows. We note that the coefficient of the distance is higher than the other estimates but is in accordance with other papers[17.]

[17] See Peter Egger (2000).

5. Conclusion

In this article, we have investigated trade flows between CEEC and OECD countries using recent developments of panel data techniques with fixed effects, which permit to control the individual heterogeneity and hence, to avoid biased results. Indeed, it is now well known that the use of conventional time-series and cross-section methods do not allow to control for unobservable heterogeneity and hence, are likely to produce biased results[18]. Our empirical results enable us to draw the following conclusions:

(i) From an econometric point of view, the use of the HT method to estimate the gravity model appears the most convenient for our data sample. More particularly in the presence of correlation between some explanatory variables and the unobserved characteristics (here the unobserved bilateral effect), this method produces consistent parameter estimates contrary to the GLS method. Besides, in contrast to the standard within estimator the HT method allows to derive parameter estimates for the time-invariant variables (such as the geographic distance, the common border, the common language). Our econometric estimations reveal that the country size and the geographical distance variables have a crucial impact in international trade flows explanation and are the most important sources of this correlation.

(ii) From an economic point of view, trade flows existing between CEEC and OECD countries, that is, two sets of heterogeneous economies with different levels of economic development are inter-industry and vertical intra-industry trade. The vertical intra-industry trade was stimulated by the multinational firms, which developed a labour intensive production segment in CEEC countries due to their comparative advantage and their less expensive labour costs than in developed countries. The positive coefficient of the DGDPT variable, which represents a proxy of comparative advantage intensity, emphasized that the economic distance

18 See Badi H. Baltagi (2001).

between OECD and CEEC countries constitutes the specialization main determinant of these countries on various branches according to their comparative advantages (inter-industry trade), as well as on some qualitative segments within these branches (vertical intra-industry trade). But these types of trade do not actually lead to convergence, the main goal of Central and Eastern European countries. Indeed, economic convergence is associated to an horizontal intra-industry trade, which assumes the existence of simultaneous exports and imports flows of comparable sizes inside the same branch, that is, similar products of the same quality, of the same technology and an important added value. Consequently, horizontal intra-industry trade is an indicator of the convergence degree between countries. However, this type of trade is less developed between CEEC and OECD countries and the tendency to an economic convergence in the short run is unlikely for CEEC countries, since there exist no competing but only complementary market segments. In fact, trade flows are essentially stimulated by price competitiveness.

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