Monopolistic Competition, Gravity Model and International Trade between Continents

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SUMMARY

In our paper we discuss the gravity equation using the most complete treatment of Debaere [2005] with an analysis of economic positions of various continents and countries in the period of 11 years (1995-2005). However, unlike Debaere, we do not constrain our analysis to the split between OECD and non - OECD – countries. First, we analyze trade between pairs of countries and aggregate the results to illustrate trade between continents (meant as groups of countries). Then, we split countries on every continent into two groups: developed and developing ones. We analyze trade not only between developed countries, but also between developing ones, and between developed and developing ones. We got confirmation of the Helpman's theorem even for developing countries. In majority of cases of inter – continental trade we confirm increasing similarity of trading partners and therefore trade expansion. This result is not surprising for trade between developed countries (Europe and North America), but seems to be very interesting when taking into consideration the less developed African ones.

Keywords: International trade, gravity models
JEL classification: F15

1 Introduction

Last decade of international cooperation was comparable to an eruption of a volcano. This is particularly true for the Asian countries. Below we examine how these changes in empirical evidences influenced theoretical findings. Specifically, we test if the Helpman's theorem can be applied only to the developed countries, as it was originally meant, or we can prove the same relations for the less developed countries. In our analysis we will also cover all countries in the world. The way we do this is to divide the world into continents, treating some of them as generally "developed" (Europe, North America) or "less developed" (Africa). Then we rerun our test for developed and developing countries, split according to the World Bank classification.
The paper is organised as follows: in section 2 we present theoretical background, section 3 presents the results of our empirical research, and the last section consists of conclusions.

2. Theoretical Background

In the simplest form of the gravity equation, it is expected that bilateral trade between two countries is directly proportional to the product of the countries' GDPs[1]. The further expectation is that bigger and more similar countries tend to trade more intensively with each other than the smaller and differentiated ones. Such gravity model with its more sophisticated versions has been for years constituting "the workhorse for empirical studies" in international economics (Eichengreen, Irwin [1997]).

In this setting, the trading countries produce differentiated goods for international monopolistic competitive markets. In a model of monopolistic competition with open economies trading freely with varieties of many final products, each country specializes in production and export of different types of final products.

The demand is assumed to be identical and homothetic across analyzed countries. When countries trade with each other, every good produced in any country is – by assumption – shipped to all other countries in quantities proportionate to GDP of the purchasing country (it is in fact similar to the standard macroeconomic approach with marginal propensity to import multiplied by GDP equal to the value of import[2]).

We test the implication of the monopolistic competition model for the aggregate international trade pattern. Before doing this we present an overview of the literature and theoretical work that link trade and GDP similarities. We base on Helpman's [1987] derivations of testable implications of a monopolistic competition model.

In our analysis we use multicountry framework in which:

– $i, j=1,\ldots,C$ denote trading countries,

– $k=1,\ldots, N$ denotes products (we assume any variety of a good is a distinct product)

– y_k^i denotes country *i's* value of production of good *k*.

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[1] This model can be seen as a simplified form of a general equilibrium trade model explaining the typical (normal) level of trade between countries. It was first applied by Helpman [1987]. It can be supplemented with dummy variables introduced into the gravity equation to account for deviations from the simple model (and therefore from the typical level of trade) that are difficult to be measured quantitatively (e.g. the impact of common language or border, participation in a preferential trade agreements).

[2] However, different marginal propensities to import express international differences in demand characteristics and are therefore more realistic than assumption of identical demand structures across analyzed countries. For further research of influence of differences in demand see new works of Feenstra and Venables.

In our framework, GDP of country i is a sum of values of production of all goods k (k = 1,…, N) manufactured in the analyzed country i (i = 1, …, C):

$$Y^i = \sum_{k=1}^{N} y_k^i \tag{1}$$

Consequently, the global GDP is the sum of GDPs of all countries i:

$$Y^W = \sum_{i=1}^{C} Y^i \tag{2}$$

Further, we denote share of country i in global GDP as s^i:

$$s^i = Y^i \big/ Y^w \tag{3}$$

If trade is balanced in every country i, then s^i denoting country's i share in the global GDP influences intensity of bilateral trade between i and j. As we measure each country's import as a fraction of its GDP, then with balanced trade it is equal to its partner's export. In our research we concentrate on export of all countries, avoiding therefore disturbances resulting from the non-zero costs of international trade (e.g. tariffs and other measures of trade policy, transport and insurance costs). Therefore, export of product k from country i to country j is equal to:

$$X_k^{ij} = s^j y_k^i \tag{4}$$

X_k^{ij} in equation (4) depends on s^j because export from i to j is equal to j's import from i, and the latter one depends on GDP of country j.

Summing up values of export of all products k manufactured in country i we get i's total export to j (with the assumption of balanced trade it is equal to i's import from j and therefore equal j's export to i):

$$X^{ij} = \sum_k X_k^{ij} = s^j \sum_k y_k^i = s^j Y^i = \frac{Y^j Y^i}{Y^w} = s^j s^i Y^w = X^{ji} \tag{5}$$

Summing up the first and the last elements of the equation (5) we get the total trade of the analyzed pair of countries, defined as a sum of their exports (in case of both countries it is equal to the partner's import):

$$X^{ij} + X^{ji} = \left(\frac{2}{Y^w}\right) Y^i Y^j \qquad (6)$$

Formula (6) is the simplest derivation of the gravity equation. It shows that the intensity of bilateral trade depends on product of GDPs of both trading countries.

The re-formulation of equation (6) with the formula (5) confirms that size of the country and the difference between the trading partners matter:

$$X^{ij} + X^{ji} = 2 s^i s^j Y^w \qquad (7)$$

A variable representing size of a country is its share in the world's GDP. Different values of these shares by trading partners express the differences in their shares. In particular, two countries of unequal sizes will not trade as intensively as two countries of similar sizes would do[3].

The further extension of the gravity approach goes into evaluation of a role of the member countries in an economic region and evaluation of economic position of a region in the global economy. In the simplest setting we have two countries (*i*, *j*) constituting region A. GDP of A is therefore equal to:

$$Y^A = Y^i + Y^j \qquad (8)$$

We define the relative shares of GDPs of every country in the regional GDP and the GDP of A relative to the global GDP as, respectively:

$$s^{iA} = \frac{Y^i}{Y^A} \qquad s^A = \frac{Y^A}{Y^w}$$

Volume of *A*'s trade relative to *A*'s GDP depends on the position of every member country in the region and on the relative importance of the region's GDP in the world:

$$(X^{ij} + X^{ji}) / Y^A = 2 s^{iA} s^{jA} s^A \qquad (9)$$

where:

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[3] If sizes of both countries are equal $s_i = 0{,}1$ and $s_j = 0{,}3$, then their sizes influence bilateral trade with coefficient 0,064. If they both were equal in size and would have exactly the same joint share in the world's GDP as in the previous example $s_i = s_j = 0{,}2$, then the respective coefficient would be bigger than before (0,08). With shares $s_i = 0{,}1$ and $s_j = 0{,}01$ and coefficient 0,024 we can see that smaller countries trade less intensively (though if they were equal $s_i = s_j = 0{,}055$ their trade would be more intensive – coefficient 0,0605).

$s^{iA} + s^{jA} = 1$

because region A consists of just two countries.

Reformulating the right hand side of the equation (9) we get:

$$2s^{iA}s^{jA} = 1 - (s^{iA})^2 - (s^{jA})^2 \qquad (10)$$

Equation (10) presents a simple version of Helpman's theorem [1987] formulated under the following assumptions: both trading countries are fully specialized in their outputs, tastes in both countries are identical and homothetic, trade is free worldwide. In Helpman's theorem, the volume of trade relative to GDP is proportional to the dispersion index defined for the region A as:

$$disp = 1 - \sum_{i \in A} (s^{iA})^2 \qquad (11)$$

This conclusion is visualised in equation (12), which is a further reformulation of equations (9) and (10). In equation (12) volume of export from region A relative to A's GDP depends on the share of A's GDP in global GDP (s^A) and on the size dispersion index of A's members:

$$\frac{X^A}{Y^A} = s^A (1 - \sum_{i \in A} (s^{iA})^2) \qquad (12)$$

where N – number of countries in the region A (in our setting $N = 2$).

The size dispersion index in brackets in equation (12) is maximized for countries of the same relative size. E.g. for a region consisting of two identical countries this index is equal to 0,5. In case of big dispersion (if one country's share tends to be close to 1), the index is near to 0 (e.g. if one country's share is 0, 99 and the other one's is 0,01, the index is less than 0,02).

Equation (12) shows that volume of trade in the region is related to the relative size of countries constituting the analyzed region. It is expected that with increasing similarity of trading partners their bilateral trade will intensify.

Helpman [1987] tested his theorem for OECD countries. He confirmed his hypothesis for OECD countries for which trade based on monopolistic competition seemed to be of importance. Helpman's method was used by different authors. Hummels and Levinsohn [1995] first chose for their test not only OECD, but also non-OECD countries (which stands for countries for which one can expect low intra-industry trade (IIT)). They constructed the panel and tested whether the trade model gets empirical support for partners for which it is not meant (pairs of countries whose trade is characterized by low IIT). They confirmed Helpman's findings for OECD countries. However, for non-OECD countries they could not reject the results of their test. This was very surprising, as they found that theory that was designed to explain trade among developed countries found some support among developing countries as well. This result was revisited by Debaere [2005] who also provided an econometric test of Helpman's prediction for pairs of countries.

Building on Helpman's idea, Debaere [2005] proposed a more complete treatment and transformed Helpman's equation (6). He used the linear form of the equation (12):

$$A = \{i, j\}$$

$$\ln\left(\frac{X^{ij} + X^{ji}}{Y^i + Y^j}\right) = \ln(s^i + s^j) + \ln\left[1 - \left(\frac{Y^i}{Y^i + Y^j}\right)^2 - \left(\frac{Y^j}{Y^i + Y^j}\right)^2\right] \qquad (13)$$

Debaere also analyzed the surprising results for non-OECD countries obtained by Hummels and Levinsohn who tested the following equation:

$$\ln\left(X_t^{ij} + X_t^{ji}\right) = \alpha_{ij} + \beta \ln\left[(1 - dispersion_t^{ij})(Y_t^i + Y_t^j)\right] + \varepsilon_t^{ij} \qquad (14)$$

Debaere argued that by using the equation (14) with Y on the right hand side Hummels and Levinsohn allowed size of a country to have impact on the estimation.

By using different econometric techniques and different measures of GDP Debaere found that for OECD countries the coefficient of similarity index is significant and positive. As in the work of Helpman [1987] and Hummel and Levinsohn [1995] this coefficient was statistically different from its theoretical value of 1. In Debaere [2005] it varies from 0,25 to 1,57 depending on the econometric technique. In contradiction to Hummel and Levinsohn, Debaere proved that the index of similarity does not play a significant role in trade of non-OECD countries. We extend this work analyzing the same equation as Debaere did, but we do this for different groups of countries.

3. Empirical research

We provide an econometric test of Helpman's prediction for pairs of countries by extending Debaere's analysis on other groups of countries as well as on different methods of measuring GDP. First we test the gravity equation for available pairs of countries from all continents as dependent variable. Then we divide countries on every continent into two groups: developed and developing ones and test the gravity equation for available pairs of countries from respective groups from all continents[4].

In our estimations we base on equation:

$$\ln\left(\frac{X_t^{ij}+X_t^{ji}}{Y_t^i+Y_t^j}\right)=\alpha_{ij}+\gamma\ln(s_t^i+s_t^j)+\beta\ln\left[1-dispersion_t^{ij}\right] \qquad (15)$$

Equation (15) is a reformulated version of Debaere's equation (13). In formula (15) α_{ij} represents fixed effects and can account for bilateral transportation costs, language barriers, cultural barriers, tariffs or distance. Similarity index lnsim = ($\beta\ln\left[1-dispersion_t^{ij}\right]$) represents the impact of dispersion index on bilateral trade. This index shows how the volume of trade is related to the relative size of countries (we assume that there are *C* countries in the analysed region). Index sim is maximized for countries of the same relative size, in which case [1 – $dispersion^{ij}{}_t$] is equal to (1-(1/*N*)). If countries share approach 1, the value of index sim is close to 0.

The size index lns = ($\gamma\ln(s_t^i+s_t^j)$) represents the impact of country shares on the intensity of trade. This index varies over time. We estimate the impact of changing GDP shares on trade because in the time period covered by our analysis (11 years) these changes can be significant.

The literature does not deliver any standard measure of GDP used in the tests of gravity model. The authors use different measures of GDP, only rarely explaining why they choose just these. Therefore, we use three measures of GDP but we report the results only for current GDP in US$. We argue that exports are collected in current prices so the most appropriate measure for the share of trade in GDP is GDP in current prices. The other researches use also GDP in PPP in current international $. We think that this measure is particularly unfavorable for developing countries whose GDP in PPP is increasing compared to GDP in current US$.

We did three types of estimations. First, we analyze trade between pairs of countries and aggregate the results to illustrate trade of each continent (meant as groups of countries) with the whole world. These are reported in Table 1 for two types of GDP measures (for current GDP and

[4] In the second test we resign from presentation of results relatedto Australia's trade, because of its low importance in the world trade flows.

GDP in ppp). Second, we divide countries into two groups: developed and developing ones, following the World Bank classification. The results are reported in table 2 also for the above mentioned two types of GDP (current US$ and PPP in current international $). Then we analyze bilateral trade between pairs of countries and aggregate the results to illustrate trade between continents. These results are reported in Table 3 only for GDP in current prices.

To do the research we used the data from Comtrade database for trade and WDI dataset for GDP. We analyze the period 1995 - 2005. We use the panel data techniques of estimation using STATA. In all cases a fixed effects model specification is preferred to a random effects model based on a Hausman test.

The most surprising result of our analysis compared to the results of Debaerre (2005) is the positive and statistically significant β coefficient for all countries and continents. It is positive not only when we aggregate the pairs of countries into the continents, but also when we divide countries into two groups: developing and developed ones.

Helpman's theorem finds confirmation in the fact that β coefficient is always bigger for developed countries than for developing ones. Summarizing, we can state that the volume of trade relative to GDP is proportional to the dispersion index not only for developed countries but also for developing ones.

Table 1. Tests of the Gravity Equation with Value of (Trade/GDP) for Pairs of Countries as Dependent Variable for different measures of GDP, results reported for countries grouped to continents. Trade of continents with world

	Europe	North America	Asia	South America	Australia	Africa
Lns (GDP - current US$)	0.504	0.266	0.702	-0.256	0.727	-0.242
	(18.49)**	(3.97)**	(18.86)**	(4.73)**	(5.81)**	(4.17)**
lnsim (GDP - current US$)	**1.081**	**0.95**	**1.032**	**0.718**	**1.302**	**0.477**
	(47.52)**	(17.40)**	(31.39)**	(15.46)**	(12.01)**	(10.44)**
Constant	-3.754	-5.366	-3.132	-9.17	-2.946	-9.994
	(23.71)**	(12.21)**	(13.69)**	(26.67)**	(3.92)**	(25.16)**
Observations	39071	11007	26185	10600	3213	17789
Number of group(k1 k2)	5003	1703	4117	1389	584	3278
R-squared	0.40	0.30	0.41	0.06	0.39	0.10

	Europe	North America	Asia	South America	Australia	Africa
Lns (GDP - PPP, current international $)	0.964	-0.084	2.646	1.045	2.248	0.996
	(13.98)**	-0.5	(31.45)**	(7.18)**	(5.92)**	(6.28)**
lnsim (GDP - PPP, cur. international $)	**1.533**	**0.777**	**1.673**	**1.251**	**3.038**	**0.883**
	(29.22)**	(6.48)**	(24.48)**	(10.06)**	(10.96)**	(7.42)**
Constant	-1.456	-8.092	5.595	-2.588	7.227	-3.496
	(3.76)**	(8.25)**	(11.96)**	(3.11)**	(3.41)**	(3.53)**
Observations	37636	10345	24832	10226	3102	17558
Number of group(k1 k2)	4741	1600	3858	1298	558	3206
R-squared	0.35	0.18	0.24	0.21	0.34	0.10

Absolute value of t statistics in parentheses
significant at 5%; ** significant at 1%

In table 1 we present bilateral trade of countries from all continents with the whole world. We got general support for Helpman's theorem, though positive and significant β coefficient in case of Africa is surprising.

When we compare the results for each continent we can see that β coefficient is much bigger for continents with more developed countries than for Africa when using current GDP. The low coefficient is surprising for North America for GPD in PPP what can be the result of the small openness of US economy.

Using data of GDP in current prices we obtained relative big and negative constant effects (α_{ij}). We suppose that it can be the evidence of negative influence of price changes on intensity of trade.

Negative numbers of γ coefficient for South America and Africa shows increasing share of these continents in the world current GDP negatively influencing openness of their economies. If we analyse the results for GDP in PPP we see that γ coefficient is negative for North America.

Table 2. Tests of the gravity equation with value of (Trade/GDP) for pairs of countries as dependent variable for different measures of GDP, results reported for countries grouped depending of their level of development

	Developed economies & Developed economies	Developing economies & Developed economies	Developing economies & Developing economies
lns (GDP - current US$)	0.829	0.414	0.087
	(25.83)**	(11.23)**	(2.58)**
lnsim (GDP - current US$)	**1.639**	**0.934**	**0.721**
	(61.36)**	(34.17)**	(22.65)**
Constant	-0.544	-4.939	-7.291
	(3.50)**	(23.33)**	(30.47)**
Observations	12566	27424	41235
Number of group(k1 k2)	1124	3688	7670
R-squared	0.42	0.41	0.15

	Developed economies & Developed economies	Developing economies & Developed economies	Developing economies & Developing economies
lns (GDP - PPP, current international $)	0.14	1.332	1.936
	-1.73	(15.00)**	(21.90)**
lnsim (GDP - PPP, current international $)	**2.166**	**1.494**	**1.112**
	(32.68)**	(23.27)**	(14.81)**
Constant	-2.84	-0.306	1.923
	(6.78)**	-0.62	(3.49)**
Observations	12566	26463	38979
Number of group(k1 k2)	1124	3516	7198
R-squared	0.20	0.41	0.02

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

The results reported in Table 2 seem to be the most significant for the research. First of all, they give confirmation of Helpman's theorem not only for developed countries and trade between them. Interesting and compatible to the theoretical predictions is the β coefficient bigger for developed countries then for other trade partners. Also the lowest β coefficient for trade between developing countries is important. That means that Helpman's theorem is more meaningful for developed then for developing countries. These results are repeated for both measures of GDP.

Table 3. Estimations of the gravity equation with value of (Trade/GDP) for pairs of countries as dependent variable for different measures of GDP, results reported for countries grouped to continents. Trade between continets

Europe with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	0.648	0.236	1.013	-0.096	0.654	-0.406
	(19.33)**	-1.78	(18.02)**	-0.99	(2.99)**	(4.41)**
lnsim (GDP - current US$)	**1.258**	**0.711**	**1.537**	**0.838**	**1.319**	**0.433**
	(39.54)**	(7.53)**	(29.50)**	(11.86)**	(5.36)**	(7.08)**
Constant	-1.676	-6.848	-0.73	-8.459	-3.943	-10.678
	(9.01)**	(8.94)**	(2.21)*	(15.07)**	(3.32)**	(19.21)**
Observations	14324	3569	9377	3690	1095	6605
Number of group(k1 k2)	1488	519	1301	427	180	1050
R-squared	0.50	0.36	0.48	0.07	0.60	0.02
North America with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	0.236	0.538	1.188	-0.274	3.228	-0.91
	-1.78	(4.81)**	(7.16)**	-1.84	(5.83)**	(3.07)**
lnsim (GDP - current US$)	**0.711**	**0.664**	**1.527**	**0.911**	**3.263**	**0.46**
	(7.53)**	(4.29)**	(11.02)**	(7.24)**	(8.67)**	(2.60)**
Constant	-6.848	-3.072	-0.245	-8.091	13.754	-12.753
	(8.94)**	(3.16)**	-0.24	(7.53)**	(4.10)**	(8.14)**
Observations	3569	2248	2160	1660	324	1012
Number of group(k1 k2)	519	352	368	218	53	188
R-squared	0.36	0.26	0.46	0.16	0.63	0.03
Asia with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	1.013	1.188	0.81	-0.031	1.217	0.227
	(18.02)**	(7.16)**	(11.18)**	-0.28	(5.27)**	(2.16)*
lnsim (GDP - current US$)	**1.537**	**1.527**	**0.976**	**0.48**	**1.547**	**0.488**
	(29.50)**	(11.02)**	(13.69)**	(5.00)**	(6.80)**	(6.13)**
Constant	-0.73	-0.245	-1.785	-8.853	0.726	-7.368
	(2.21)*	-0.24	(3.92)**	(13.60)**	-0.49	(10.58)**
Observations	9377	2160	6577	2439	831	4584
Number of group(k1 k2)	1301	368	1083	331	158	845
R-squared	0.48	0.53	0.34	0.12	0.56	0.29
South America with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	-0.096	-0.274	-0.031	-0.408	0.016	-1.061
	-0.99	-1.84	-0.28	(4.06)**	-0.07	(3.83)**
lnsim (GDP - current US$)	**0.838**	**0.911**	**0.48**	**0.597**	**0.533**	**0.239**
	(11.86)**	(7.24)**	(5.00)**	(5.30)**	(3.04)**	-0.93
Constant	-8.459	-8.091	-8.853	-8.49	-8.988	-16.084
	(15.07)**	(7.53)**	(13.60)**	(12.07)**	(6.51)**	(8.11)**
Observations	3690	1660	2439	1455	302	990
Number of group(k1 k2)	427	218	331	146	41	216
R-squared	0.07	0.15	0.12	0.10	0.49	0.60
Australia with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	0.654	3.228	1.217	0.016	-0.565	0.534
	(2.99)**	(5.83)**	(5.27)**	-0.07	(2.80)**	-1.2
lnsim (GDP - current US$)	**1.319**	**3.263**	**1.547**	**0.533**	**-0.766**	**1.358**
	(5.36)**	(8.67)**	(6.80)**	(3.04)**	(3.03)**	(4.62)**
Constant	-3.943	13.754	0.726	-8.988	-13.476	-4.378

	(3.32)**	(4.10)**	-0.49	(6.51)**	(7.24)**	-1.62
Observations	1095	324	831	302	182	459
Number of group(k1 k2)	180	53	158	41	64	86
R-squared	0.60	0.63	0.56	0.49	0.63	0.25
Africa with	**Europe**	**North America**	**Asia**	**South America**	**Australia**	**Africa**
lns (GDP - current US$)	-0.406	-0.91	0.227	-1.061	0.534	-0.244
	(4.41)**	(3.07)**	(2.16)*	(3.83)**	-1.2	-1.75
lnsim (GDP - current US$)	**0.433**	**0.46**	**0.488**	**0.239**	**1.358**	**0.403**
	(7.08)**	(2.60)**	(6.13)**	-0.93	(4.62)**	(2.67)**
Constant	-10.678	-12.753	-7.368	-16.084	-4.378	-10.278
	(19.21)**	(8.14)**	(10.58)**	(8.11)**	-1.62	(8.89)**
Observations	6605	1012	4584	990	459	4101
Number of group(k1 k2)	1050	188	845	216	86	883
R-squared	0.21	0.03	0.29	0.08	0.25	0.02

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

The analysis of results reported in Table 3 also brings confirmation of theoretical predictions. Even if we do estimations and report the results for trade between continents we see that β coefficient is still positive and significant. For trade of more developed and open countries β coefficient is bigger.

4. Conclusions

We got full confirmation of Helpman's theorem for developed countries. However, in all analyzed cases we can confirm increasing similarity of trading partners (positive sim). Therefore we can expect trade expansion. It means that we got positive values of β coefficient even for trade between developing countries. This result is not surprising for trade between developed countries and less developed ones. Of course, our research proves that the developed countries become much more similar than other groups of partners and therefore they are expected to trade more intensively than any other pairs of countries are. The results of our research are sensitive to methods of GDP measurement.

In our opinion, increasing similarity even of very different countries can be the result a.o. of intensified cooperation in production between countries. It may change the characteristics and reasons for trade with growing intensity of trade in semi products. As for the theory, it can result in necessity of substituting the gravity approach with a new theory or supplemented gravity model with additional elements.

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