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Econometric Estimation of a Gravity Model for the External Trade of Romania

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Abstract

The gravity model is frequently used to analyse bilateral trade statistics. In the paper we will identify, exclusively for Romania, the significant factors of influence on bilateral trade flows. As factors, we will consider the clasical gravity variables and some suplimentary dummy variables. Also, we will determine, using the estimated equation of the gravity model, the efficiency of Romanian international trade with its partners.

Keywords: External trade efficiency, econometric trade model, gravity variables, Romania.

Introduction

The gravity model is widely used in econometric analysis of international statistics. For the foreign trade, the gravity model analyses the determinants of bilateral trade flows, the goal being the development of more precise predictions on the bilateral trade.

Newton's gravitational equation measures the maximum force between two masses that are separated in space. Trade gravity equation follows the same principle, measuring trade that may exist between two countries, mainly depending on the distance between them and their level of development, plus a few specific factors.

Literature review shows two time periods of intensive use on empirical gravity model of trade, separated by a period of theoretical foundations of the model. The first uses of gravity equations are from 1960, in 1962 when Tinbergen and then, in 1963, Pőyhőnen applied the gravity model to explain the commercial trade between two partner countries using the classical equation, in which the factors are the product of GDP's of the two countries (positive correlation) and geographical distance between the two partners (negative correlation).

Then followed a time period of theoretical background for the gravity model, mainly through the scientific works of Anderson (1979), Bergstrand (1985, 1989), Armington (1969), Helpman and Krugman (1985) and Deardorf (1988).

After 2000, the papers are highly empirical, extending the model with a number of factors that show geographical, historical or economic relationships between the partner countries.

This paper is empirical and aims to identify significant influence factors on bilateral trade flows between Romania and its trade partner countries, in order to estimate the degree of the external trade efficiency, identifying the most effective and most ineffective foreign trade partnership for Romania. The econometric model used for this purpose is not a proper gravity model, since we only used the bilateral trade flows between one reference country, Romania, and its trading partners, but it uses gravity variables as explicative factors.

Methodology and Data

The standard expression for the trade gravity ecuation is:

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$$F_{ij} = C\frac{GDP_i \cdot GDP_j}{D_{ij}}$$, unde

- F_{ij} represents the bilateral trade flows between country *i* and country *j*;

- *C* is the constant of the equation;

- GDP_i is the gross domestic product for the country *i*;

- D_{ij} is the distance between the capitals of the two partner countries.

The equation is linearised using the logarithm function, and the gravity model of trade will have the following form:

$$\ln F_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j - \beta_3 \ln D_{ij} + \varepsilon$$

In addition to these traditional explanatory variables, the model may include a number of additional variables, dummy or not, geographical, historical or economic, relevant to explain trade between two partner countries. Glick and Rose (2002) have introduced a number of additional variables, such as the existence of common borders, a common language, a common currency and some variables showing colonial links between the two countries - a variable indicating whether one was current or past colonized by the other, and a variable showing whether the two countries have the same colonizer. Franklin, Stream and Wei (1995) included, as economic variables, a number of variables that indicate the stage of development of partner countries in terms of production factors - human capital, physical capital and land.

The econometric model proposed in this paper to explain Romania's trade with partner countries of the world, has the following form:

$$\ln BTF_i = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln DIST_i + \beta_3 FDI\_dummy + \beta_4 BORD\_dummy + \beta_5 EU\_dummy + \varepsilon,$$ where

- BTF_i represents the bilateral trade flows between Romania and the country *i*. The values of this variable are obtained as the sum of exports and imports between the two countries in 2009, expressed in millions of euro;

- GDP_i is the gross domestic product of the partner country *i*, expressed in dollars at purchasing power parity, in 2009;

- $DIST_i$ is the distance in kilometers between Bucharest and the capital of the partner country *i*;

- FDI_dummy is a dichotomical variable that indicates whether the partner country made significant direct investments in Romania or not. The variable takes the value 1 for the partner countries that had, in 2009, over 100 million euros investments in Romania, and 0 otherwise;

- BORD_dummy is a dichotomical variable and shows whether Romania has territorial or sea borders shared with the partner country. The variable has value 1 if there is a common border and 0 if countries don't have common borders;

- EU_dummy is a dichotomical variable and has the value 1 if the partner country is an EU member and 0 otherwise.

The data used in the analysis are from World Bank, World Trade Organisation, Eurostat and the Romanian National Institute of Statistics. The database contains 74 partner countries with which Romania has bilateral trade. Were excluded those countries for which, in 2009, there were either import or export operations only with Romania.

Estimation of the Econometric Trade Model

Parameters were estimated using Ordinary Least Squares method, and for the selection of the regression variables was used the stepwise method.

The parameters of the econometric model were estimated with SPSS 17.0 software.

Table 1 shows the square of the correlation coefficient values (R Square) obtained for the models based on all the regression factors. It is noted that from the 5 variables entered into the model, the best model selected has four significant influence factors, namely $lnGDP_i$, $lnDIST_i$, FDI_dummy and BORD_dummy. The chosen model explains 67.5% from the variation of the dependent variable, the bilateral trade flows between Romania and partner countries. The variable EU_dummy did not contribute significantly to the explain of the bilateral trade.

Table 1. R Square Statistics for the Selected Models Using Stepwise Method

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.548[a]	.301	.291	1.58865
2	.643[b]	.414	.397	1.46460
3	.741[c]	.550	.530	1.29307
4	.822[d]	.675	.656	1.10614

a. Predictors: (Constant), FDI_dummy

b. Predictors: (Constant), FDI_dummy, BORD_dummy

c. Predictors: (Constant), FDI_dummy, BORD_dummy, lnGDP

d. Predictors: (Constant), FDI_dummy, BORD_dummy, lnGDP, lnDIST

e. Dependent Variable: BTF

The analysis of the data presented in Table 2, ANOVA results, shows that the models explained significant variation in bilateral trade flows, based on factors included in the model (Sig. <0.05), but we can observe that the model with the lowest residual error is the fourth model, the one that, consequently, has the highest R Square value.

Table 2. ANOVA Result for the Selected Models

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	78.155	1	78.155	30.967	.000[a]
	Residual	181.714	72	2.524		
	Total	259.870	73			
2	Regression	107.572	2	53.786	25.075	.000[b]
	Residual	152.298	71	2.145		
	Total	259.870	73			
3	Regression	142.828	3	47.609	28.474	.000[c]
	Residual	117.041	70	1.672		
	Total	259.870	73			
4	Regression	175.445	4	43.861	35.848	.000[d]
	Residual	84.424	69	1.224		
	Total	259.870	73			

a. Predictors: (Constant), FDI_dummy

b. Predictors: (Constant), FDI_dummy, BORD_dummy

c. Predictors: (Constant), FDI_dummy, BORD_dummy, lnGDP

d. Predictors: (Constant), FDI_dummy, BORD_dummy, lnGDP, lnDIST

e. Dependent Variable: BTF

Analysing the results presented in Table 3 for the fourth model, the estimated trade equation is:

$$\ln BTF_i = -8.68 + 0.71 \ln GDP_i - 0.956 \ln DIST_i + 0.801 FDI\_dummy + 1.179 BORD\_dummy$$

The results show that bilateral trade flows (BTF) are explained by GDP, the distance between the two countries, the partner country's foreign direct investment in Romania and the existence of common borders between Romania and the partner country.

The positive correlation between:

- BTF and GDP shows that Romania has more intense external trade with countries that have higher GDP than with the countries with lower GDP;
- BTF and FDI_dummy shows that Romania has more intensified trade activities with countries that invested more than 100 million euros, compared to countries with low or zero foreign direct investment;
- BTF and BORD_dummy shows that Romania has a bigger trade volume with countries having a common border, territorial or by sea.

The negative correlation between BTF and the geographical distance shows that the greater the distance between Romania and the partner country, the lower is the trade volume between the two.

Tabel 3. Parameter Estimates of the Trade Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.972	.225		8.779	.000
	FDI_dummy	2.195	.395	.548	5.565	.000
2	(Constant)	1.728	.217		7.951	.000
	FDI_dummy	2.270	.364	.567	6.232	.000
	BORD_dummy	2.034	.549	.337	3.703	.000
3	(Constant)	-9.333	2.416		-3.862	.000
	FDI_dummy	1.705	.344	.426	4.952	.000
	BORD_dummy	2.388	.491	.396	4.864	.000
	lnGDP	.431	.094	.400	4.592	.000
4	(Constant)	-8.680	2.071		-4.191	.000
	FDI_dummy	.801	.343	.200	2.339	.022
	BORD_dummy	1.179	.481	.195	2.451	.017
	lnGDP	.710	.097	.658	7.334	.000
	lnDIST	-.956	.185	-.503	-5.163	.000

a. Dependent Variable: BTF

Model errors were tested for normality and independence. The results are presented in Tables 4 and 5. The assumption that the errors are normally distributed is accepted (Sig. = 0.777> 0.05), as well as the error's independence hypothesis (Sig. = 0.64> 0.05).

Table 4. Validation of Normality Hypothesis

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		74
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	1.07540674
Most Extreme Differences	Absolute	.077
	Positive	.077
	Negative	-.064
Kolmogorov-Smirnov Z		.660
Asymp. Sig. (2-tailed)		.777

a. Test distribution is Normal.

b. Calculated from data.

Table 5. Validation of the Independence Hypothesis

Runs Test

	Unstandardized Residual
Test Value[a]	-.05535
Cases < Test Value	37
Cases >= Test Value	37
Total Cases	74
Number of Runs	40
Z	.468
Asymp. Sig. (2-tailed)	.640

a. Median

Determination of Efficient and Inefficient Trade Partnerships for Romania

To analyse the efficiency of Romania's bilateral trade with a partner country, we have analysed the model error series that resulted from estimating the trade model. Negative error values shows that the real value of the BTF is below the estimated one, and positive error values indicate that the real value is greater than the estimated value. The working hypothesis is that negative error values indicate an inefficient trade, which has not reached its potential and positive error value show an effective trade, above the theoretical potential.

To determine the degree of trade efficiency or inefficiency, we calculated, for the error series, the one standard deviation interval around the mean, which is (-1, +1). If the error values are outside the range, then for positive values there is a high efficiency of bilateral trade and for negative values we have a highly inefficient trade. The result is presented in Table 6.

Table 6. The Degrees of Efficiency for the Bilateral Trade Flows between Romania and the Partner Countries

Country	Area	e_i	Efficiency level
Austria	EU	0.62	Efficient
Belgium	EU	0.65	Efficient
Bulgaria	EU	0.33	Efficient
Czech Rep.	EU	0.82	Efficient
Cyprus	EU	0.08	Efficient
Denmark	EU	-0.91	Inefficient
Estonia	EU	-0.26	Inefficient
France	EU	0.76	Efficient
Finland	EU	0.01	Efficient
Germany	EU	1.25	Highly efficient
Greece	EU	-0.56	Inefficient
Ireland	EU	0.02	Efficient
Italy	EU	0.98	Efficient
Latvia	EU	-0.71	Inefficient
Lithuania	EU	-0.68	Efficient
Luxembourg	EU	-1.35	Highly inefficient
Malta	EU	-0.42	Inefficient
Nederlands	EU	0.76	Efficient
Poland	EU	0.51	Efficient
Portugal	EU	-0.01	Inefficient
Slovakia	EU	1.32	Highly efficient
Slovenia	EU	1.31	Highly efficient
Spain	EU	0.31	Efficient
Sweden	EU	-0.7	Inefficient
UK	EU	1.39	Highly efficient
Hungary	EU	0.55	Efficient
Norway	AELS	-0.79	Inefficient
Switzerland	AELS	-0.46	Inefficient
Belarus	Europe	-0.84	Inefficient
Bosnia	Europe	-0.32	Inefficient
Croatia	Europe	-0.31	Inefficient
Russian Fed.	Europe	-0.1	Inefficient
Moldova	Europe	0.53	Efficient
Macedonia	Europe	-0.26	Inefficient
Serbia	Europe	-0.17	Inefficient
Turkey	Europe	-0.99	Inefficient
Uckraine	Europe	-0.69	Inefficient
Saudi Arabia	Asia	-0.63	Inefficient
United Arab Emirates	Asia	-0.21	Inefficient
Jordan	Asia	-1.05	Highly inefficient
Iran	Asia	-0.35	Inefficient
Lebanon	Asia	-0.36	Inefficient
Georgia	Asia	0.53	Efficient
Azerbaidjan	Asia	-0.58	Inefficient
Israel	Asia	-0.86	Inefficient
Hong-Kong	Asia	0.02	Efficient
Korea	Asia	1.48	Highly efficient
Malaysia	Asia	0.39	Efficient
Singapore	Asia	0.15	Efficient
Taiwan	Asia	3.58	Highly efficient
Thailand	Asia	0.23	Efficient
China	Asia	1.48	Highly efficient
India	Asia	0.36	Efficient
Indonesia	Asia	-0.56	Inefficient
Japan	Asia	-0.33	Inefficient
Pakistan	Asia	-1.54	Highly inefficient
Sri-Lanka	Asia	-1.58	Highly inefficient
Kazahstan	Asia	2.64	Highly efficient
Uzbekistan	Asia	-1.52	Highly inefficient
Egypt	Africa	-0.46	Inefficient
Libya	Africa	0.32	Efficient
Morocco	Africa	2.11	Highly efficient
Tunisia	Africa	0.25	Efficient
Cote d'Ivoire	Africa	2.85	Highly efficient
South Africa	Africa	-0.01	Inefficient
Ethiopia	Africa	-2.08	Highly inefficient
USA	North America	-0.78	Inefficient
Canada	North America	-1.72	Highly inefficient
Mexico	Central America	-0.8	Inefficient
Argentina	South America	0.26	Efficient
Brazil	South America	0.68	Efficient
Chile	South America	-2.35	Highly inefficient
Colombia	South America	0.17	Efficient
Australia	Oceania	-1.41	Highly inefficient

Analysing the data in Table 6, we see that, regarding the area, Romania has the most efficient bilateral trade with EU countries, the rest of European partners deploying ineffective trade relations with Romania, the only exception being Moldova. It has the most inefficient bilateral trade with the countries in the Middle Asia. The most effective partnerships are with Germany, Slovakia, Slovenia, United Kingdom, Korea, Taiwan, China, Kazakhstan, Morocco, Cote d'Ivoire, and the most ineffective partnerships are with Luxembourg, Jordan, Pakistan, Sri Lanka, Urbekistan, Ethiopia, Canada, Chile and Australia.

Concluding Remarks

In this paper we presented an external trade model, derived from a gravity model, in order to identify significant explanatory variables for bilateral trade between Romania and partner countries. Based on the obtained model error values, we determined the partners and areas to which Romania develops, efficient or inefficient, foreign trade activities.

The results for Romania confirm existing studies. Thus, bilateral trade flows (BTF) are explained on the one hand, by the GDP of the partner country, by the FDI in Romania and the existence of a common border, between which we have positive ccrrelations, and other hand, the distance between the two countries, which has a negative correlation with BTF.

Values for the model errors showed an efficient bilateral trade with EU member states and an inefficient one with the other European countries, and the best trade partnerships are with European, East and Southeast Asian countries.

The analysis was carried out for exports and imports of both goods and services, but recent studies have shown differences between the trade models of goods and the trade model of services, so a further study for the building of a sectorial model for external trade would be very useful.

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