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GRAVITY MODEL APPROACH FOR EXPORTS ANALYSIS OF REPUBLIC OF MOLDOVA BETWEEN 2010 AND 2021

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Abstract: *This paper explores the effects of determinants of bilateral trade on export flows of Republic of Moldova during last decade in the framework of gravity model. Being a structural model with solid theoretical foundations it proves that markets are linked and changes in one partner country can cause changes in trade performance of another partner country. The variables include trade partner's GDP, economic distance, and Association Agreement membership. Specifically, the model relies on a fixed effect panel estimation for explaining the export flows of the Republic of Moldova. In order to check the viability of the gravity equation, there are* executed *statistical tests. Based on the analysis, there are provided policy recommendations for trade policy.*

Keywords: *gravity model, panel data, Republic of Moldova, export, Association Agreement*

JEL Code: *F17*

Introduction

Quantitative and detailed information of trade flows is necessary at different stages of the policy-making process. In recent years, trade as a part of globalization process has become increasingly contractionary and having detailed and reliable analysis of factors influencing external trade is crucially important. Gravity model has been one of the main methods for analyzing international trade flows for many years. It is also considered to be one of the most widely used and effective economic applications in economics. There are several arguments that explain the success and popularity of this approach, provided by researchers:

> The gravity model represents a realistic general equilibrium environment that simultaneously accommodates multiple countries, multiple sectors, and even firms. As such, the gravity framework can be used to capture the possibility that markets are linked and that trade policy changes in one market will trigger ripple effects in the rest of the world. (Yoto et al., 2016)

Forcasting ability is considered to be one of the most advantageous features of the gravity model. Empirical gravity equations of trade flows permanently ensure matching between 60 and 90 percent with summary data for both goods and services.

Gravity model is viable because countries with high economic growth are disposed to spend large amounts on imported goods and services using their great incomes. Simultaneously they also occupy a large share of other countries' imports because they produce a wide range of products. So, other things equal, the higher is GDP of every country involved in trade, the larger is the trade between these countries.

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World Bank Group defines Moldova as a small lower-middle-income economy. Economic growth and prospects are related to its performance in international and regional markets. Strong reliance on the exports of a few commodities and high concentration of trade flows in previous years has generated vulnerability towards changing external economic conditions. Recently Moldova's economy has been crucially affected by the affairs in Russian Federation, that had been one of the largest export destinations for Moldova for a long time. During the last decade took place intensification of economic relationships with the European Union (EU). Legal framework for this phenomenon is Deep and Comprehensive Free Trade Agreement (DCFTA) as part of the Association Agreement signed in 2014. This is one of the reasons that provided increasing economic linkages with European region.

Influence of economic performance of partner countries and possible effects of Association Agreement calls for an assessment of trade performance through a gravity model. In other words, the aim of this paper is to estimate the influence on Molodva's export performance of the following trade determinants: "economic distance" to export-destination countries, economic growth of trade partners and of Association Agreement, that is considered major trade policy implication of the last decade. All these variables are estimated through gravity model, that is considered a suitable option to fulfil this task. (Goschin, 2016)

1. Literature review

One of the first attempts to explain the phenomenon of growth in international trade after World War II was the similarity theory of countries by Stefan Linder, who in 1961 published his essay on trade and transformation. After analyzing the changes in international trade, Linder came to the conclusion that international trade in manufactured goods occurs as a result of the similarity of consumer preferences from different countries at the same level of economic development. According to the Swedish economist, companies, when looking for new opportunities to sell their products, find that the most promising foreign markets are the markets of those countries in which the preferences of buyers are similar to the needs and demands of domestic consumers. (Linder, 1961)

After Linder's work and up to the present day, several new theories have been published explaining the volume and characteristics of bilateral trade between countries.

Economists often estimate a general gravity model of the following form:

$$\boldsymbol{Trade\ Flows_{it} = \beta_0 * \frac{GDPi\ \hat{}\ \beta 1 * GDPt\ \hat{}\ \beta 2}{Dij}} \quad (1)$$

This equation says that the three things that determine the volume of trade between two countries are the size of the two countries' GDPs and the distance between the countries, assuming that trade is proportional to the product of the two GDPs and inversely proportional to distance, where β_0 , β_1, β_2 are chosen to fit the actual data as closely as possible.

Estimated gravity models show a powerful negative influence of distance on international trade. This decline reveals increased costs of logistics. Researchers have

calculated that a "1 percent increase in the distance between two countries is associated with a fall of 0.7 to 1 percent in the trade between those countries." (Krugman, 1979)

There are other factors that can significantly affect trade: personal contact, cultural affinity, trade agreements. For example, elaborated based on the gravity model shows, that the United States register larger trade flows with its neighbours than it does with European countries of the same size. Gravity models are used by economists as a technique of evaluating the influence of trade agreements on actual international trade: if a trade agreement is effective, it should lead to significantly more trade among its partners than one would otherwise predict given their GDPs and distances from one another. It is common, that trade agreements imply cancellation of all formal barriers to trade between countries, nevertheless, their national borders do not become insignificant. Consequently, there is much more trade between regions of the same country than between equivalently situated regions in different countries.

> This phenomenon can be illustrated on the example of Canadian–U.S. border. Both countries are parts of a free trade agreement, they have common English language and a minimum of formalities while crossing the border for citizens of either country. Nevertheless, trade statistics shows that there is much more trade between provinces than between provinces and U.S. states. (Krugman, 1991, p. 142)

In the 1980s American economists Krugman and Lancaster explored new theoretical principles for describing laws of international trade. They argued that companies can obtain sustainable competitive advantages through investment in research and development, intellectual property rights, economies of scale and opportunities provided by their experience. The most important component of Krugman's work was the concept of increasing returns, assuming that a proportional increase in all factors of production leads to an increase in the output of the product. "It shows that trade need not be a result of international differences in technology or factor endowments. Instead, trade may simply be a way of extending the market and allowing exploitation of scale economies, with the effects of trade being similar to those of labour force growth and regional agglomeration." (Krugman, Obstfeld & Melitz, 2012).

As a result, P. Krugman came to conclusions that are similar to Linder's theory. Krugman proved that countries trade similar goods with each other due to lowering barriers of international trade. This contributes to the appearance of competition between companies from different countries. At the same time, "this model was created on the analysis of trade among developed industrial countries with each other, and he repeatedly emphasized that his theories are of little use to trade between developed and developing countries." (Smirnov, 2020, p 53).

In addition to these fundamental theories of trade, modern science uses an econometric approach to study international trade. The econometric tools of gravity modelling have been significantly enriched in recent decades due to the accumulation of large amounts of information on bilateral trade relations between countries, the

development of computer technology. Also, theoretically explained modifications were applied to gravity equation.

A variable, named "multilateral resistance", which characterizes the average value of barriers to trade with all other trading partners under consideration, underlying importance of facilitation of trade was introduced by Anderson (1979).

Additional explanatory variables like transport costs, the influence of natural and political boundaries, membership in monetary and trade unions, and many other factors have been recently introduced in the gravity model. All these studies were systematized completely by Anderson and van Winkoop (2004).

2. Geografic structure and dynamics of trade flows of Republic of Moldova during 2010 and 2021

For better assessment of variables and understanding of the current situation of external trade of the Republic of Moldova, author consider it necessary to make a preliminary analysis of Republic of Moldova trade flows based on statistical data.

In 2021, merchandise exports totalled 3144.4 million US dollars, a value higher by 27.5% compared to that recorded in 2020. Exports of goods destined for the countries of the European Union (EU-27), in 2021, totalled 1919.4 million US dollars (17.0% more compared to 2020), holding a share of 60% in total exports

In 2021, the main destination countries of goods exports, which held 89.7% of total exports, were: Romania (26.5% of total exports), Turkey (10.0%), Russian Federation (8.8%), Germany (7.8%), Italy (7.6%), Switzerland (3.8%), Poland (3.5%), Ukraine (3.0%). (Figure 1).

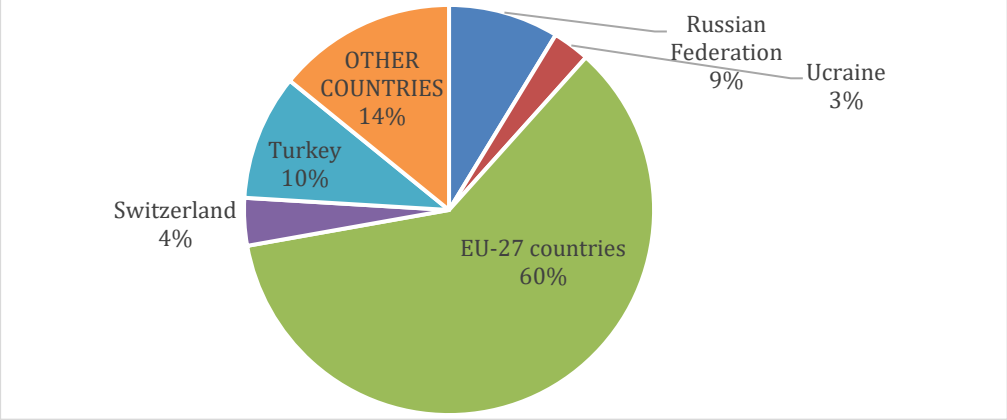

Figure 1. Structure of exports of Republic of Moldova per countries and geographical destinations in 2021, in per cent.

Source: Author's elaborations, based on data of National Bureau of Statistics (2022).

In recent decade, Moldova has progressively decreased its traditional export dependence on the Russian market. The share of Moldovan exports going to Russian Federation dropped from 28,2% percent in 2011 to 8,8% in 2021. Especially it marked a sharp decrease by 40% after signing the Association Agreement between European Union and Republic of Moldova and due to tariff and non-tariff measures that were imposed.

Share of exports to Ukraine also decreased roughly from 7% in 2010 to 3% in 2021 mostly due to military conflict in the East of the country. (Table 1)

At the moment, Romania holds 1st place as geographic destination of exports. Indeed, exports to Romania grew in 2.2 times during last decade. Moldovan exports to Turkey expanded significantly. In fact, Turkey receives 10 percent of exports, becoming the second most important market.

Table 1. Share of partner countries in total exports of Republic of Moldova in evolution

Country/ year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Russian Federation	28,2%	30,3%	26,0%	18,1%	12,2%	11,4%	10,5%	8,1%	9,0%	8,8%	8,8%
Ukraine	6,9%	5,7%	5,8%	4,7%	2,3%	2,4%	2,7%	3,0%	2,9%	2,8%	3,0%
Germany	4,8%	3,2%	4,7%	5,9%	6,0%	6,2%	6,9%	8,1%	8,9%	9,1%	7,8%
Italy	9,7%	9,4%	7,6%	10,4%	10,0%	9,7%	9,7%	11,4%	9,6%	8,7%	7,6%
Poland	3,9%	3,4%	3,5%	2,8%	3,5%	3,6%	4,2%	3,6%	4,1%	4,4%	3,5%
Romania	17,0%	16,5%	16,9%	18,6%	22,7%	25,1%	24,8%	29,3%	27,5%	28,6%	26,5%
Turkey	3,3%	2,6%	5,2%	4,5%	3,3%	3,0%	4,3%	4,0%	6,3%	7,0%	10,0%

Source: Author's calculation based on data of National Bureau of statistics (2022) and National Bank of Moldova (2020).

Taking into consideration trade in evolution, we observe decreasing export trade flows with Russian Federation and markable increasing with Romania. (Figure 2)

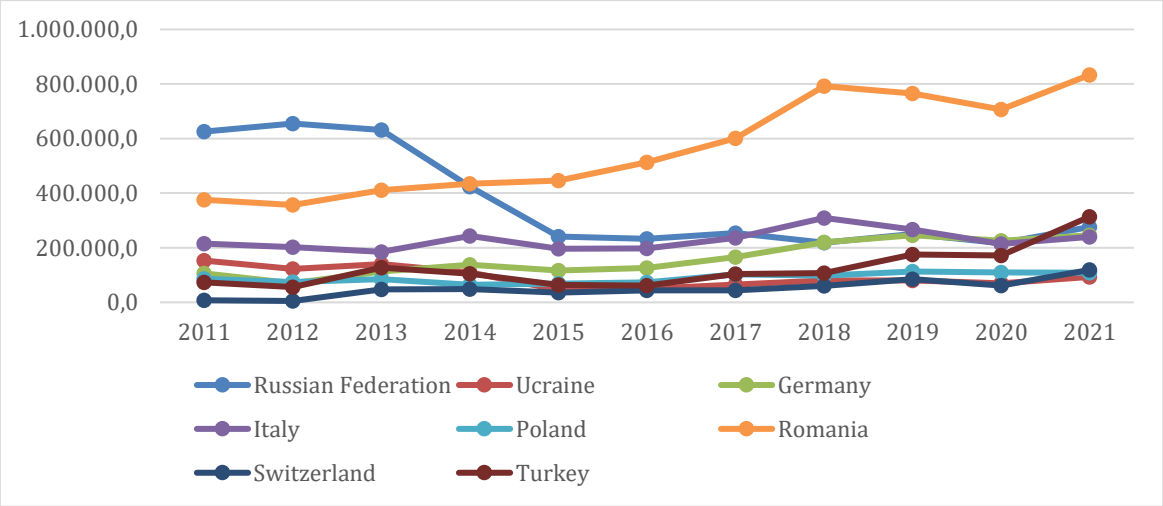

Figure 2. Exports Evolution of Republic of Moldova with major partners from 2011 to 2021, thousand dollars.

Source: Author's calculations based on data of National Bureau of Statistics (2022).

So, in this context, the DCFTA follows the natural trends of intensifying trade relations between the European Union and the Republic of Moldova in recent years, because traditionally, free trade zones are established between trade partners that show both desire and capabilities to develop bilateral trade. Thus, the removal of barriers to export and import with the main trading partner will obviously contribute to the further intensification of trade

and economic relations between both parties. The increase in the importance of the European Union market is also reflected in the structure of exports by product.

3. The Model and Findings

Equation (2), representing the theoretical gravity equation that governs bilateral trade flows, consists of 3 variables. The selection of explanatory variables is based on the international literature, in the context of the current data availability limitations.
Based on classical model of gravity we transformed (model 1) in

$$EXPORT = \beta_0 * \frac{GDP\_CAP\_PPP \,\hat{}\, \beta 1 * AT \,\hat{}\, \beta 3}{DIST\_EC \,\hat{}\, \beta 2} \quad (2)$$

In order to estimate the previous equation, relation *(2)* is transformed into a log-log pool model by taking logarithms of both its sides:

$$ln\ EXPORT_{it} = ln\beta_0 + \beta 1 * ln\ GDP\_CAP\_PPP_{it} + \beta 2\ ln\ Dist\_EC_{it} + \beta 3\ AT_{it} \quad (3)$$

where β_1, β_2 and β_3 are elasticities. β_0 is an intercept

"The panel data structure enables to account for specific period on the basis of panel model with the fixed-effects". (Baltagi, 2005, p.12-14)

The model specification in *(3)* changes accordingly:

$$ln\ EXPORT_{it} = \beta_{0i} + \gamma_t + \beta_1 ln\ GDP\_CAP\_PPP_{it} + \beta 2\ ln\ Dist\_EC_{it} + \beta 3\ AT_{it} + \varepsilon_{it} \quad (4)$$

i – country; there are 18 partner countries taken for analysis, that's why i range is 1..18;
t – year, sample consists of values taken from 2010 to 2021, meaning that observation period is 11 years.
γ_t represents period fixed effects such as general shifts in business cycle, economic crises, new technology, etc.) that affect all countries in a similar manner.
β_{0i} reflects cross-section fixed effects (country characteristics that are constant over the period of interest: territory, clime, customs; economic policy)

Accuracy of fixed effects' model is confirmed by checking for the absence of individual effects through Fisher test application.

The null hypothesis of the test is $H_0: \beta_{0i} = 0, i=1,...,N,$ which implies the absence of individual effects and recommends pool, while the alternative is the fixed effects model. Given test shows the value of F statistic=64,84. In this case, the null hypothesis is rejected, meaning that there are no effects at the 1% significance level.

Table 2. Description of variables used for research

Variable name	*Description*	*Data source*
Export	*The value of export flow from Republic of Moldova to each partner country (total 18 partners), thousand dollars.*	*National Bureau of statistics*
GDP_CAP_PPP	*represents GDP per capita of each trade partner, purchasing parity power, USD, dated 2017.*	*World Bank database*
DIST_EC	*is an "economic distance" that is computed as distance between capital of Moldova and capital of the trade partner country divided by the share of the partner-country in world GDP.*	*Google map and World Bank*
AT	*Dummy variable taking the value 1 from the 2014, when the Association Agreement (AA) has been signed*	*Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Moldova, of the other part*

Source: author's calculations

If the panel data model proves to be appropriate for the dataset chosen, then there are two options to choose: the fixed effects (FE) and random effects (RE) model. The problem is solved by applying the Hausman test. For the case of panel data, the null hypothesis of the test implies that FE and RE estimators do not differ significantly. (Baier & Bergstrand, 2009).

The test implemented rejects the null hypothesis, meaning that random effects cannot not be used because they may be correlated with the independent variables in the model. The variables of the models are presented in Table 3.

This model is verified using statistical tests. The data used for estimating the models cover the period 2010 to 2021 and include 18 countries: Belarus, Bulgaria, Switzerland, Russian Federation, Greece, Ukraine, Germany, Italy, Poland, Check Republic, Spain, Turkey, China, Hungary, Romania. These countries were chosen based on the preliminary statistical analysis meaning that these partner countries have the biggest share in total exports of Republic of Moldova.

The coefficient of determination R^2, which is one of the quality criteria of the obtained regression model, shows that the behaviour of the model is approximately 88% explained by the included explanatory variables - regressors. In modern model research practice, the Fisher test is used to check the quality of the coefficient of determination R^2.

With the help of the Fisher-test, it is verified significance of joint explanatory ability of the regressors. If the obtained Fisher value exceeds the tabular value for the corresponding level of significance, then the null hypothesis is rejected, and the regressors jointly explain the behaviour of the studied variable, namely "EXPORT". In this estimated model $F_{stat} = 68.4$, therefore the null hypothesis is rejected and the alternative hypothesis is accepted, that the obtained model is adequate to the real data.

Table 3. Results of the estimated panel model with fixed effects

Dependent Variable: LOG(EXPORT)
Method: Panel Least Squares
Sample: 2010 2021
Periods included: 12
Cross-sections included: 18
Total panel (balanced) observations: 216

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(GDP_CAP_PPP)	2.984913	0.534514	5.584351	0.0000
LOG(DIST_EC)	1.286876	0.597797	2.152699	0.0326
AT	0.247307	0.117711	2.100961	0.0369
C	-29.79812	9.046106	-3.294028	0.0012
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.875198	Mean dependent var		10.82874
Adjusted R-squared	0.862397	S.D. dependent var		1.282918
S.E. of regression	0.475896	Akaike info criterion		1.444932
Sum squared resid	44.16305	Schwarz criterion		1.773084
Log likelihood	-135.0526	Hannan-Quinn criter.		1.577506
F-statistic	68.37357	Durbin-Watson stat		0.702955
Prob(F-statistic)	0.000000			

Source: calculations made by author in Eviews

The Student's test allows to determine the statistical significance of each regressor separately. If the regressor is statistically insignificant, according to the Student's test, then such a regressor can be defined as not influencing the studied variable and cancelled from the model. Student's test is carried out by taking into account 2 hypotheses: the null hypothesis about the statistical insignificance of the parameters and the alternative hypothesis about the significant influence of the regressor on the studied variable. If $t_{stat} > t_{crit\ (0.05;\ 212)} = 1.96$, then the null hypothesis is rejected and the alternative hypothesis is accepted, that the obtained model is adequate to reality.

Using the Student's test gives us the possibility to identify the contribution of each regressor to the behaviour of the studied variable. The goal is to determine the degree of influence of factors, and the Student's test is an important contribution. All variables proved to be statistically significant in the model. After calculation there is obtained the model (5)

$$Ln\ (Export) = 2.985 * ln\ (GDP\_CAP\_PPP) + 1.287 * ln\ (DIST\_EC) + 0.247 * AT - 29.798 \quad (5)$$

This equation is interpreted as follows:

Estimated coefficients correspond to the expected theoretical assumptions. The obtained positive value of 2.985 the explanatory variable GDP_CAP_PPP means that if

GDP per capita increases in the countries of the trading partner for export, then the estimated export to these countries can increase by 2.99%

The correct sign was also obtained in the DIST_EC regressor, which implies direct relation between economic distance and the potential export. Economic distance implies that the more developed in the economic partner, the less is the influence of physical distance.

Control variable AT demonstrates positive value, that characterized significant role of signing the Association Treaty. To a greater extent, Moldova's exports are affected by explanatory variable GDP per capita, purchasing power parity prices.

Conclusions

An empirical relationship known as the gravity model helps to explain the value of trade between any pair of countries and reveals the obstacles that continue to limit international trade in modern global economy. Gravity model explains how the value of trade between any two countries depends on the size of these countries' economies and explain the reasons for that relationship. Also, it emphasizes that an important condition for trade development is considered absence of trade barriers and presence of trade partners with a similar level of purchasing power of the population.

The geographical destination of exports of Republic of Moldova has changed over time. Recent decade has been marked by a large increase of share of European Union in export destination of Republic of Moldova, with gradual reduction of trade flows to Russian Federation. Evolution of trade relations with Russian Federation was marked by the introduction of certain trade measures concerning Moldova, that influence trade negatively. It is recommended to restart the discussions with the authorities of the Russian Federation in order to reassess the restrictive measures applied to goods of Moldovan origin.

Exports to European Union remain concentrated to four main partners, meaning that changes in economic situation of these countries can influence trade flows of Republic of Moldova. The gravity model proves that signing and implementing of the Association Agreement (AA) has positive influence on the export flows of the Republic of Moldova. In order to benefit from trade with the EU under the DCFTA, it is important to contribute to the competitiveness of domestic products on foreign markets through the implementation of recommendations, improving quality system and implementing and ensuring a viable system in the field of standardization, metrology and conformity assessment.

General assumptions of gravity model are confirmed by the elaborated model and the equation can be used to check how exports of Moldova respond to changes in economic performance of partner country, to changes in economic development of partner country, and membership of the same trade agreement.

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