LEXONOMICA
Vol. 14, No. 2, pp. 187–212, December 2022

THE GRAVITY MODEL OF TRADE: THE CASE OF CENTRAL AND EASTERN EUROPE

Accepted
22. 8. 2022

Revised
28. 9. 2022

Published
1. 12. 2022

NAZARII LYPKO
Ivan Franko National University of Lviv, Economic department, Lviv, Ukraine
nazar.lypko@gmail.com

CORRESPONDING AUTHOR
nazar.lypko@gmail.com

Abstract The main patterns of international trade in the countries of Central and Eastern Europe have been analysed in the paper. The gravity model, estimated for a large sample of bilateral trade flows for the analysed states, has been used as a benchmark. The model has been updated according to the modern conditions in the international economy. The emphasis has been made on the analysis of products' trade since the trade of services requires separate modelling. The purpose of the paper was to find the main factors that determine gravity trends in international trade in Central and Eastern Europe. It has been proven that the distance between countries and their gross domestic products are still crucial factors which determine trade flows between them. Additionally, the influence of the product structure of export has been considered. A higher share of value-added export increases bilateral trade between the countries. Common past for the analysed countries boosts trade between them because of the presence of historical trade traditions and the development of regional production agglomeration. It has been proven that the gravity equation remains a simple and reliable model of the factors which determine the trade between countries.

Keywords
the gravity model, international trade, exports, imports, the gravity equation, international economy, international trade flows, bilateral trade

https://doi.org/10.18690/lexonomica.14.2.187-212.2022

University of Maribor Press

1 Introduction

The gravity model is a simple empirical model of international trade, which explains trade flows between countries based mainly on their gross domestic product (GDP) and the distance between them. Therefore, GDP and distance between countries are independent variables, while the size of trade flows between countries is dependent. If the model is reliable, local countries with large GDPs must become regional trade centres, which would accumulate the majority of trade flows in a particular geographical area. The regional trade centres can impact the economic development of all the other countries around them and influence the economy of the whole region. For instance, a recession in such a centre will cause a fall in the revenues of its main exporters. Second of all, regional trade centres can define the product structure of export of their trade partners and, respectively, the direction of their national economies' evolution. The existence and influence of the regional trade centres predefine the necessity and efficiency of free trade areas or unions.

The gravity model of international trade claims that the volume of trade is directly correlated with the economic potential of both countries (which is traditionally reflected via GDP) and inversely proportional to the distance between them (which reflects the transport costs) (Chaney, 2013). The greater the GDPs of the countries, the greater their ability to produce and consume a certain amount of goods and services. The model also studies the impact of such factors as the presence of a common border, common language, common history and duration of economic cooperation, membership in international trade or economic unions, the degree of infrastructure development, *etc.* All these variables can be united under the term "institutional component", which determines the direction, intensity and character of international trade. The economic potential of countries and the distance between them are real variables in the model, while the equation may additionally include a range of the so-called dummy variables. These variables have been different in different research at different stages of the model's development. Some of them lose their topicality while new institutional factors occur.

Traditionally, the model is applied to a pair of countries, bilateral trade between which is studied. The research under consideration studies the trade flows inside a group of countries and with their main trade partners in the whole region. The proposed model has a dynamic character since it studies the development of the trade for 23 years (analysis is made for the period since 1996). The overall number

of observations has exceeded more than 2000, which makes the model valid and reliable. Scientists and researchers have not previously devoted enough attention to the application of the model to the countries from Central and Eastern Europe. The article considers the application of the model directly to this group of countries. A lot of denotative events have happened for these countries, since that time, including the financial crisis of 1998, the entrance to the European Union, and the global financial crisis of 2008. Finally, the research considers a relationship between the geographical and product structure of exports. It may have a significant influence on the geographical structure of the international trade of a country.

Development of transport infrastructure, technological growth, and ongoing globalisation should have changed the character of international trade and the main factors influencing it. The impact of the distance should have been minimised, while the solvency of the countries, reflected in their GDPs, had to remain the main determinative factor of trade. Globalisation, technological development, and the development of transport infrastructure minimise the importance of logistics and transport infrastructure for international trade. The existence of such institutions as the European Union (hereinafter: EU) had to guarantee the equal allocation of trade flows and overall economic potential between the countries of the region. The countries from the union had to reach a high level of economic convergence and approach their levels of economic development. It can be supposed that the presence of vivid trade leaders in the region undermines such a hypothesis. Bilateral trade between countries is mainly determined by economic potential, while institutional factors may enforce or undermine the influence of other factors on international trade. Despite the character of the determinative factors of foreign trade, there are always regional trade leaders who can influence the economic development of all their trade partners and the whole region.

In light of the above, the research paper answers the following questions. Whether globalisation and technological advances have led to the minimisation of the role of distance as an impact factor for international trade. Whether the existence of the EU and, respectively, trade preferences have changed traditional trade patterns of the countries from Central and Eastern Europe? Whether product structure of a country's export-import operations is able to impact its geographical structure of export-import flows? Whether the CEE countries develop trade relations with their closest neighbours with a common past and sometimes common culture? Is it beneficial for these countries to trade with the regional trade leaders?

The paper first analyses the trade flows of the CEE countries and their main trade partners in the conditions after the global financial crisis of 2008. The period brought serious challenges to the region, including the Eurozone debt crisis of 2009. They may have led to a redistribution of the trade flows among the countries. Previously the researchers paid less attention to this region. This subject is definitely interesting in the context of the common cultural and historical past of these states. In particular, these countries were members of the socialist block with a planned economy and centralised trade flows. The paper also creates novelty in the field of adding a new variable to the model – the product structure of the export operations.

Taking into account the object and the research questions, the paper has the following structure: literature review, methodology, discussion, results, conclusions and policy suggestions. The previous theoretical achievements and the modern trends in the subject are discussed in the literature review section. The next section describes the main methodological instruments and the model itself, which are used to study the object. The author analyses the main trends and patterns in the product and geographical structure of international trade of the CEE countries in the discussion section. The section results are devoted to regression analysis of the international trade of the countries under consideration. Finally, the main conclusions and recommendations are made in the last section of the paper. Special attention is paid to policy suggestions in the countries of the region.

2 Literature review

Theories and models of international trade have been an integral element of international economics for decades. The most well-known theories of international trade are the following: the theory of absolute advantage, the theory of comparative advantage, the specific factors model, the Heckscher-Ohlin model, the monopolistic competition model, the new trade theory, *etc.* (Shahriar and Qian, 2019: 21–42). Some of these models are mainly theoretical, while others are closer to empirical instruments. The latter are easier and more effective to use for the analysis of real international trade flows and the development of an effective trade policy. The gravity model is among such models.

The gravity model has traditionally been at the centre of discussions in the area of the international economy. The historical roots of the gravity equation can be traced to 1885, while the beginning of the gravity model as an empirical instrument is monitored from 1962 to 1966. Theoretical justification of the gravity equation and the model has lasted for decades. Nowadays, it is a period of revival and revision of the traditional gravity model according to the existing conditions and new institutional factors. The following economists have paid a lot of attention to the development of the gravity model in international trade: Jan Tinbergen, James Anderson, Elhanan Helpman, Jeffrey Bergstrand, John McCallum, Paul Krugman, *etc.* Jan Tinbergen is considered to be the founder of the gravity model. He was inspired by Newton's law of universal gravitation and declared that the trade flows between two countries are directly proportional to the economic potential of the countries and inversely proportional to the distance between them. This was the basis of the gravity equation, which was introduced by Tinbergen in his work titled "Shaping the World Economy" (1962) (Shahriar and Qian, 2019: 21–42). The gravity equation, according to Tinbergen, is expressed as follows:

$$Trade_{ij} = a * \frac{GDP_i * GDP_j}{Distance_{ij}} \quad (1)$$

GDP of both countries is generally considered as the economic potential of these countries, α – is the gravity constant, according to Tinbergen, and distance is the direct geographical distance between two countries. Using logarithms, it is possible to transform the equation into a linear form suitable for analysis. Adding dummy variables to the model will transform it in the following way:

$$lnX_{ij} = lnG + \alpha_1 lnM_i + \alpha_2 lnM_j + \alpha_3 D_{ij} + \alpha_4 \varphi_{ij} + \alpha_5 N_{ij} + \alpha_6 V_{ij} + \varepsilon_{ij} \quad (2)$$

The variables are the following (the variables are explained in the order they appear in the equation above): the volume of trade between two countries; the gravity constant; the volume of exports, which can be delivered from country i to country j, accounting economic potential of country i (GDP); the size of the market of the country j (GNP); the distance between the countries as an indirect indicator of trade expenses; a dummy variable, which characterises the presence or absence of a

common border; a dummy variable, which characterises the presence or absence of preferential trade conditions between the countries (membership in some trade block, *etc.*), ε – stochastic error. The regression coefficients have been calculated using the OLS method, where 1958 trade flows between 18 countries have been studied (De Benedictis and Taglioni, 2010). This interpretation of the gravity equation by Jan Tinbergen is considered to be the first empirical application of the gravity model of international trade.

Other scientists have developed and expanded the theoretical and practical applications of the gravity model. James Anderson believed that bilateral trade flows positively react to receipts from the trade partner with an elasticity close to 1 and negatively to the world's income. Linnemann included the number of the population inside the gravity equation and gravity model, in general. Paul Krugman analysed how geographical closeness between the countries may lead to production agglomeration and the origin of the regional trade gravity centre. Scientists have not managed to expand the model significantly with new variables or revise the foundations of the model (Baier and Standaert, 2020). Recently, the gravity model has been expanded to other areas of economics research, including the analysis of foreign direct investments, international capital mobility, and the labour market.

Empirical research on the determinants of international trade using gravity models has seen significant growth in recent years. Gravity models can be theoretically derived from different classes of trade theories, including factor-endowment theories (Deardorff, 1998: 7-32), home preferences ("Armington preferences", Anderson, 1979: 106-116; Anderson and van Wincoop, 2003: 170-192; Spies and Marques, 2009: 11-35.), increasing returns to scale (Helpman and Krugman, 1985; Evenett and Keller, 2002: 281-316), incomplete specialisation models (Cieślik, 2009: 37-59) and a micro-founded general equilibrium framework (Novy, 2010: 514-545). Empirical applications include the study of trade protection (Harrigan, 1993: 91-111.), exchange rate variability (Frankel and Wei, 1993; Lizardo, 2009: 225-273; Chit *et al.*, 2010: 239-263), currency unions (Rose, 2000: 8–45; Frankel and Rose, 2002), regional versus multilateral trade agreements (Schiff and Winters, 2003; Rose, 2005; Subramanian and Wei, 2003; Cipollina and Salvatici, 2010: 63-80), home bias (Whalley and Xin, 2009: 309-319), democracy (Decker and Lim, 2009; Yu, 2010), corruption (Musila and Sigué, 2010: 129-146), development aid (Martínez -Zarzoso *et al.,* 2009), cultural specificities (Felbermayr and Toubal, 2010: 279-293; Tadesse and White, 2010: 147-152) and institutional reforms and their impact on trade

(Babetskaia-Kukharchuk and Maurel, 2004: 680-699; Babecka Kucharcukova, Babecky, and Raiser, 2012: 277-301).

The gravity model as a methodological instrument has been applied in different areas of research – international migration, international investments, and eventually, international trade. In its simplest explanation, the gravity models try to find some economic, political, and regional centres which accumulate the biggest flows from the surrounding region. Very often, the gravity model has been used to justify the creation and existence of such trade blocks as APEC, MERCOSUR, NAFTA, *etc.* (Matyas, 2002: 363–68). The model can still be used to justify the existence of trade unions in Europe or the potential creation of new blocks, for example, between the countries of Central and Eastern Europe.

After the collapse of the socialist planned economy and transition to the market economy by the countries from Central and Eastern Europe, attention to their international trade flows in new conditions has grown. The gravity model has been among the approaches applied to the analysis of their trade with new partners. Geetha Ravishankar and Marie Stack (2014) have applied the model to Eastern European countries in the conditions of transition. Transition to the market economy has been considered one of the factors which impact the patterns of international trade of a country. Aleksandra Kordalska and Magdalena Olczyk (2019) use the sink approach to define the reasons for the CEE countries' gravitation toward Germany. Despite theoretical interest in this object, there is still a lack of research that would apply the gravity model to trade within the CEE countries and with their main trading partners.

The global pandemic COVID-19 has significantly impacted the world's trade. Erginbay Ugurlu and Irena Jindřichovská (2022, 1-20), in their article, analyse how the pandemic influenced the trade of the Visegrad Group, using the gravity model. Javier Barbero and Juan Jose de Lucio (2021) explore how governments may address the challenges in the area of international trade created by the pandemic. Definitely, the influence of COVID-19 on international trade will be the object of research in the area for the next few years. The gravity model is constantly being revised nowadays by adding new variables and implementing new methodological instruments. For example, the recent revisions have included a single model for topology and weights, maximum entropy construction, maximum-likelihood parameter estimation, real-valued trade flows, *etc.* (Almog, Bird, and Garlaschelli,

2019). It can be supposed that the further development of the model is going to be related to the trade of services, which is becoming assertive nowadays. Growing attention is going to be paid to trade between developing countries. Finally, the instruments of the analysis will gravitate toward big data and machine learning. Munisamy Gopinath, Feras A. Batarseh, and Jayson Beckman (2020) applied machine learning instruments to the gravity model in agricultural trade. These instruments can be extrapolated to other areas.

3 Methodology

Economists have not reached a consensus regarding the econometric instruments which have to be used in the gravity model. The methods that are used to study the gravity trends in international trade can be divided into two groups based on their ability to eliminate the problem of zero trade flows between countries. The methods which handle the problem are the Tobit estimator and Poisson pseudo maximum likelihood. The second group is represented by the ordinary least squares method (OLS) and panel fixed data analysis (Shahriar and Qian, 2019: 21–42). These methods are quite simple to use, and they can be easily applied if the problem of zero trade flows is not the case. In the research under consideration, zero trade flows are absent in the analysed period since the selected countries represent one region and have traditionally traded a lot with each other. Panel fixed data analysis cannot be applied when, at least, one of the variables does not change over time. Geographical distance is such a variable, making it unreasonable to apply this methodological instrument. Therefore, it is possible to select the simplest method of regression analysis – OLS.

As has already been mentioned, the gravity equation is transformed to a linear form using logarithms. Traditionally, a gravity equation is expressed as follows:

$$\ln Trade_{ij} = \alpha + \beta_1 lnX_1 + \beta_2 lnX_2 + \cdots + \beta_n D_n + \varepsilon \tag{3}$$

where: Trade reflects annual trade turnover between two specific countries, X1 and X2 are independent variables, which influence bilateral trade between countries, Dn is a dummy variable, α is a gravity constant, β is the regression coefficient, and ε is a stochastic error. The selection of appropriate variables for the model defines its

overall credibility and ability to explain real economic patterns. The different variables can be added at the different stages of modelling, tracing the changes in the overall result of the model. It is essential not to overweight the model with variables in order not to miss the main factors that impact the independent variable. Taking into account previous theoretical and empirical results in gravity modelling, the modern trends in foreign trade, and specific features of the selected countries, the following independent variables are going to be included in the model:

1. GDP per capita of trade partners;
2. The population of the countries;
3. Distance between the states;
4. Quality of product structure of export (total amount of high value-added items);
5. Membership in the EU, common trade area (dummy variable 1);
6. Presence of common historical past (dummy variable 2).

The GDP of the countries is decomposed into two variables in the model – GDP per capita, as a fixed value in US dollars, and the population. The model does not observe the growth patterns in the GDPs of the countries considered. The product of these two variables is equal to the GDP of a country. However, decomposing the GDP allows differentiating between the income effect, reflected by GDP per capita, and the size of a market, reflected by population. The income effect should be the main factor which boosts the international trade of a country. However, the size of the population of a country is a reflection of the size of a potential trade market. The size of the population (size of the market) reflects an overall country's ability to consume a certain amount of goods.

Distance between countries has traditionally been considered the geographical distance between their capitals. Thus, the variable 'distance' is the actual distance between the countries, measured in kilometres. Traditionally, it is believed that the growth of distance between countries leads to a decline in the volume of trade between them. It is mainly related to the trade of products since the trade of services is not affected by distance. Such factors are geographic obstacles, geography (precipitation rates), and transport connectivity.

The quality of the product structure of exports is evaluated in the context of the share of the high-value-added items. It is supposed that a high share of value-added categories in a country's exports allows getting higher revenues from international trade and makes a country more attractive to the regional trade centres. High-value-added classes of a country's exports include the following categories: consumer goods, capital goods, machinery and electronics, and transportation.

The presence of a common border, as the typical variable for previous models, is eliminated from the model since it is partially reflected in the distance factor and common past variable. Common history, cultural past and common border are united into one dummy variable – common past. This variable also largely corresponds with such factors as common culture, language and religion. This variable is important since the common historical past may play a crucial role. For instance, production cycles may be correlated and interdependent. As a result, product agglomeration and industrial clusters may be one of the consequences of the common past and common borders between the countries.

Finally, membership in the EU demonstrates whether preferential trade conditions can critically influence the traditional historical trade patterns of a country. Such preferential trade terms are usually present in the unions like that. Membership in the EU can be replaced by membership in the Euro area since the existence of a single currency is considered a crucial factor which may influence the size of trade dramatically. The components of the gravity equation in the research paper are presented in Table 1. Therefore, the gravity equation in the research is going to be the following:

$$\ln Trade_{ij} = \alpha + \beta_1 lnY_i + \beta_2 lnY_j + \beta_3 lnP_i + \beta_4 lnP_j + \beta_5 lnD_{ij} + \beta_6 lnE_i + \beta_7 EU + \beta_8 CP + \varepsilon \quad (4)$$

The model also addresses the omitted variable bias problem. It is impossible to test for omitted variable bias except by including potentially omitted variables in the regression. Historically, the volume of trade between countries was explained by the size of their gross domestic products and the actual distance between them in kilometres. The model under consideration adds a range of new variables to the regression so as to avoid the omitted variable bias.

The omitted variable bias is one of the possible limitations of the chosen methodology. The OLS is not able to cope with the problem of zero trade flows. Zero trade flows were absent between the countries in the analysed period. That is why this limitation cannot be considered significant. Data selection and chosen methodology do not account for the trade of services, which occupies a significant share in the modern trade flows of the countries.

4 Discussion

According to the definition of OECD, Central and Eastern European countries is a term which stands for the group of countries consisting of Albania, Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, the Slovak Republic, Slovenia, and the three Baltic States: Estonia, Latvia, and Lithuania (OECD, 2001). These 12 countries have a couple of common characteristics. The most important common thing is the presence of a socialist past with a planned national economy, which defined the character of international trade. To some extent, the countries traded mainly with each other, not based on the market prices. International trade was mainly defined by some governmental agreements but not market relations between firms. The presence of the common historical past can influence international trade between countries since some historical traditions of trade may still exist between these countries. The countries were forced to transfer to international trade on market prices with market economies in the late 80s. As a result, their international trade has also changed since that time. These countries have ended the transition to a market economy after joining the EU, but they still can be treated as unstable economic systems (Alesina, Barro, and Tenreyro, 2003). Generally, the overall group of the countries of Central and Eastern Europe can be divided into three groups: Baltic states (Lithuania, Latvia, and Estonia), Balkan states and countries from Southern Europe (Albania, Slovenia, Croatia, Bulgaria, and Romania) and countries of the Visegrad Group (Poland, Slovak Republic, Czech Republic, and Hungary).

The absolute majority of the countries under consideration are net importers, which are characterised by exceeding imports over export and a negative balance of the current account. Slovenia looks like a bright exception, which has become a net exporter in the last eight years with the highest level of GDP per capita among the analysed countries. Baltic states are characterised by the highest pace of growth of GDP. At the same time, these countries have the highest average pace of inflation, which is mainly caused by hyperinflation at the beginning stages of the transition to

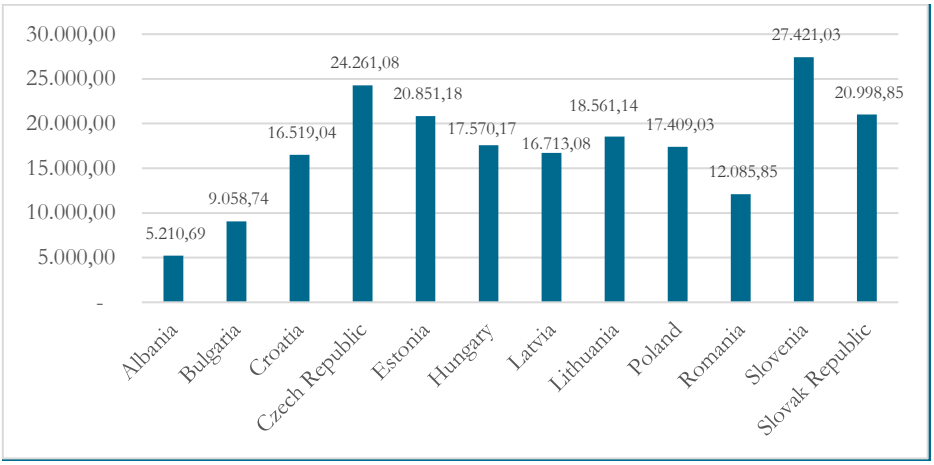
the market. Also, Baltic states are characterised by the highest average level of unemployment, which is caused by the transition to the market, the crisis of 1998, and the global financial crisis of 2008. The countries from the Visegrad Group are the richest ones among the analysed states, with the highest level of GDP per capita, the lowest level of unemployment, and the average rate of inflation. The Balkan states and the countries from Southern Europe, mainly Albania and Bulgaria, are the poorest and the most unstable. These states represent a low share in global trade and have a relatively low degree of openness of a national economy. It may reflect a correlation between a country's foreign trade and the level of economic development. Therefore, the countries of Central and Eastern Europe differ in the levels of economic development, the degree of a national economy's openness, and presence in international trade. Table 2 describes the countries' exports and imports share in a national GDP.

Looking at the data about the degree of openness of a national economy and the states' share in the global share, it is possible to make a conclusion that the analysed countries are small open economies which mainly depend on international trade conjuncture. The data about the countries' share in global trade as of 2018 is provided in the table below. The countries' share in global trade is characterised only by export operations since it is a more important indicator of a state's production possibilities. Also, the shares of imports and exports are toughly correlated. The total share of the CEE countries in global exports as of 2018 was 4.95. The CEE countries' shares in global exports are provided in Table 3.

The CEE countries are characterised by a low share in global exports. The only exception is Poland, which is characterised by a low degree of openness of a national economy and a high share in global exports, in turn. Taking into account the country's GDP per capita, it may be supposed that Poland does not realise its full economic potential. The countries cannot execute the role of the regional gravity trade centres. However, they tend to gravitate to the local economic leaders. The main macroeconomic indicators of the analysed group of countries are provided in Table 4 (the data is from 1996 to 2019).

A typical national economy of a country from Central and Eastern Europe is a small open economy with a relatively low contribution to global trade. Their economies are characterised by a high degree of openness and, respectively, vulnerability to international conjuncture. It is especially related to the Slovak Republic, with more

than 92% share of export and import in GDP as of 2019. Bulgaria, Latvia, Poland, Croatia, Romania, and Albania are exceptions to this rule. They rely on their internal markets, and they do not realise their economic potential in full potential scope. Mainly, the countries from Central and Eastern Europe are high-income countries in accordance with GDP per capita. Albania and Bulgaria are upper-middle-income countries. These are the countries with relatively high levels of unemployment and moderate inflation. Almost every state in the group is a net importer in international markets. These countries are not regional trade centres but tend to gravitate toward local economic leaders.



Graph 1: GDP per capita of the CEE countries as of 2019, USD
Source: The World Bank data from https://data.worldbank.org/indicator

The economic growth of the CEE countries strongly depends on their success in international trade. The product and geographical structure of the trade operations can impact this success. The geographical structure of the analysed countries' exports-imports operations is characterised by a high degree of concentration. The first ten major import and export partners have been analysed for each country under consideration. These top-10 countries traditionally respond for the greatest share in a country's overall exports and imports (69.76% and 70.83% for Croatia, 67.64% and 70.74% for Hungary, 68.17% and 64.39% for Slovenia, 76.09% and 68.75% for the Slovak Republic, 66.05% and 67.99% for Romania, 66.64% and 65.35% for Poland, 65.21% and 68.04% for Lithuania, 71.28% and 72.30% for Latvia, 70.82% and 63.92% for Latvia, 85.37% and 74.65% for Albania). Every

country from the group has at least one major partner in international trade. Very often, there are two or three such partners, like in the case of Croatia, Slovenia, the Slovak Republic, Romania, Lithuania, Latvia, Estonia, and Bulgaria. Usually, these major trade partners are the same as the CEE countries. Therefore, the geographical structure of trade in the region has quite a concentrated character. The main trade partners for the countries under consideration as of 2018 are provided in Table 5. It should be emphasised that the pattern for 2018 generally reflects the pattern of the previous years.

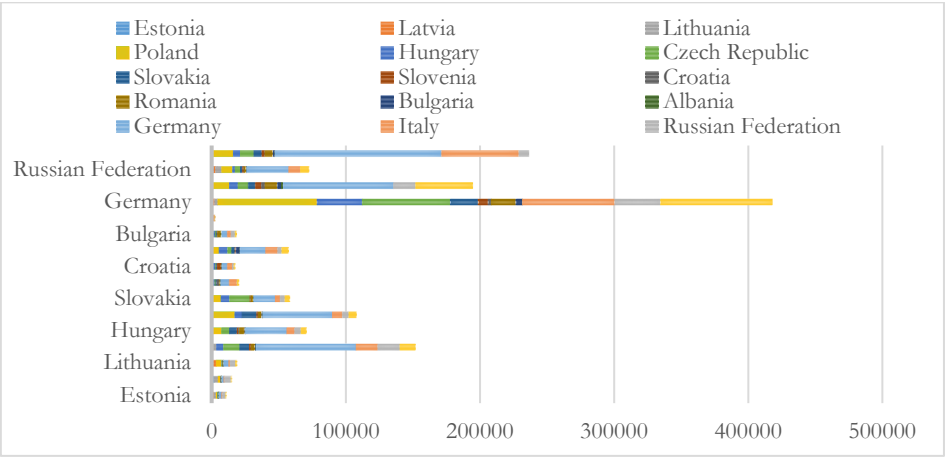
Germany looks like a powerful single economic leader in the whole region. It is the leading trade partner for almost every country in Central and Eastern Europe, including export and import operations. Generally, it is possible since the country has the largest and the most solvent market and the most efficient national economy. Germany responds to all the main criteria of the gravity model to become a regional trade leader – a large market (a high population), significant GDP and GDP per capita, and location in the centre of Europe with almost equal distance to all of the countries of Europe and CEE countries. This can be illustrated by Newton's gravity force, which was an inspiration for Jan Tinbergen when all the other economies in the region gravitated toward the largest and the most stable national economy. This is clear evidence of the gravity forces in international trade, which, in fact, does not need regression modelling.

Mainly, all the countries of Central and Eastern Europe trade with their European neighbours. Trading with the closest neighbours is economically justified since it lowers transportation and transaction costs. Moreover, trade between the European countries is truly bilateral since geographical structures of export and import are traditionally quite similar. The same situation is with the product structure of export-import operations, where the dominant classes of the products are the ones with a high-value-added. The presence of high-value-added products in their export increases revenues from foreign trade, which contributes to economic growth.

Generally, the analysed countries do not trade intensively within the groups they were divided into. An exception is the Baltic states, which actively trade with each other. Latvian geographical structure of international trade is characterised by a high presence of regional neighbours but not powerful regional economic centres. Estonia is characterised by probably the steadiest distribution of export and import geographical structure. The other analysed groups are characterised by a high degree

of concentration of trade but with a powerful economic leader outside the group. Despite the quite similar economic and business environment, historical past, and common economic challenges, the CEE countries do not gravitate intensively to each other in foreign trade. The creation of trade unions around their national economies is not the case.

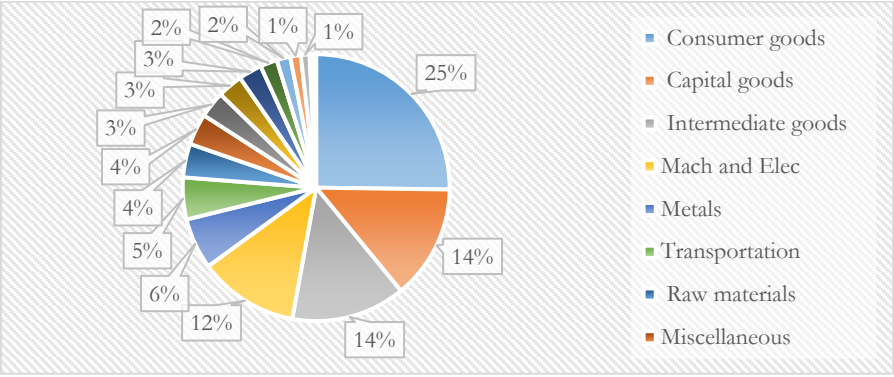
The leading countries among the trade partners of the CEE countries are the leading economies in the whole of Europe. Russian Federation can be considered an exception since it is presented in the ratings mainly due to intensive trade relations with the Baltic states. Also, its relatively high place in the ratings is associated with its export of energetic resources (oil and gas, first of all). China is presented in the rankings since it is a global leader in export. The gravity centres of international trade for the CEE countries in Europe are Germany, France, Italy, and Poland. Germany confidently occupies the first place. All these countries are characterised by a high amount of trade with the CEE countries. Also, they are present in the export patterns of every country in the CEE region. The graph below demonstrates this pattern, where the total amount of a country's export and their allocation among the analysed countries are described.



Graph 2: Geographical structure of bilateral trade between the countries under consideration, millions of USD

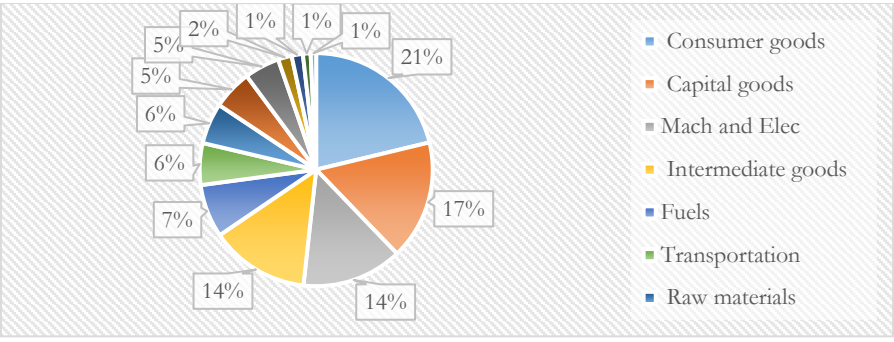
Source: World Integrated Trade Solutions by the World Bank https://wits.worldbank.org/

The product structure of the CEE export and imports is also characterised by a high degree of concertation. The overall product structure of the CEE countries' export since 1996 is provided in the Graph. The so-called high-value-added goods are dominant in the export structure of the CEE countries. According to the initial hypothesis of the research, the presence of such kinds of goods in export should make a country more attractive for trade. On the other hand, a country may be dependent on imports of specific goods, for instance, energy resources.



Graph 3: Product structure of export in the CEE countries for 1996-2018
Source: World Integrated Trade Solutions by the World Bank https://wits.worldbank.org/

The same pattern is observed in the structure of the CEE countries' imports. The product structure of the CEE countries' imports for 1996-2018 is provided in the Graph below. Generally, the product structure of export and import operations of the CEE countries proves that they can be called highly industrialised states.



Graph 4: The product structure of the CEE countries' imports for 1996-2018
Source: World Integrated Trade Solutions by the World Bank https://wits.worldbank.org/

Almost every country from Central and Eastern Europe is characterised by a high share of high-value-added goods in export and import. The product structure of exports, first of all, is a direct factor which can affect a country's economic conditions. Albania and Bulgaria have a greater share of raw materials in their export, which cannot generate sufficient and stable revenue flow from foreign trade. Respectively, their national economies look like the weakest in the region. Having high-value-added products in export, the countries from the CEE may propose a needed assortment for the mentioned leading economies of the region.

5 Results

Analysis of the geographical structure of the countries' exports and imports has shown that there are trade leaders that accumulate trade flows from all the other countries in the region. These regional trade leaders concentrate on international trade flows primarily due to their economic potential. The other factors can be identified via the application of the gravity model through regression analysis. The simplest interpretation of the gravity model of international trade is the analysis of the correlation between bilateral trade of the countries, their GDPs, and the distance between them. These are three basic variables of the gravity equation. Such calculations, using the OLS method, have been done for the CEE countries. Bilateral trade between these countries and their major trade partners (Germany, France, Italy, Russian Federation) has been considered for 2018. The results of the regression analysis are provided in Table 6 and Table 7.

The R square is 0.92, which allows talking about a high degree of correlation and significant impact of independent variables on the bilateral trade. Therefore, the gross domestic product of the countries and the distance between them can explain almost 92% of the variability in trade between states. It has been supposed in the initial hypothesis that distance must have a lower impact on trade between countries due to the development of transport infrastructure and globalisation. However, it seems that distance between countries plays a more crucial role than the gross domestic product of the countries. Therefore, the distance between countries remains a highly determinative factor in international trade, or at least in this certain modification of the model. The GDP of an exporter defines a country's ability to produce and deliver a specific amount of goods and services to the international market. The GDP of an importer is a country's ability to create sufficient demand for the products and services on the international market. Distance between

countries is an indirect indicator of the transport costs and, respectively, the profitability of a trade.

Generally, these three factors explain the patterns in international trade between the countries discussed. There is a strong positive correlation between mutual trade and GDPs and a negative one with distance. According to this specification of the equation, a 1% growth in distance between countries reduces trade between them by 1.78%. The number of observations in this first model is not enough to consider the regression model reliable. Also, the regression above does not account for the time factor. Finally, additional variables should be added to the model. The number of observations has risen to 2760 because of adding additional periods, and the model can be treated as valid. The variable of exports of the value-added products has been added to the model. At first, the regression was calculated without dummy variables. The GDP of a country has been divided into the GDP per capita and the population. Adding new variables has not changed the R square and standard error of the model. The results of this regression round are described in Table 8 and Table 9.

This specification of the regression has shown that the high-value-added export of exporters is important. The GDP of a country has been decomposed into the GDP per capita and the population. The modelling has shown that population is more important than the income effect, which is represented by GDP per capita. Therefore, the overall size of the market plays a crucial role. It is quite an obvious fact since a country with a high GDP per capita but a low population is not able to create sufficient demand to consume the proposed imports. On the other hand, an exporter is not interested in the forced allocation of its trade flows between a lot of countries because of logistics. However, it is a negative tendency for diversification and minimisation of risks. Countries must find a balance between diversification and optimisation of revenues from foreign trade.

The model under consideration also contains two dummy variables - membership of the countries in the EU and the presence of the common past between countries. Membership in the EU supposes the existence of a free trade area between countries and the absence of trade barriers and tariffs. Therefore, such variables must promote trade between countries. Common past for the countries includes historical political past, for example, existence within the borders of a single country in the past, common language and cultural heritage, production agglomeration between the

countries, similar business culture, *etc.* Usually, countries with some degree of common past also have common borders (because of that, this traditional dummy variable has been excluded from the model). Table 10 and Table 11 describes the outcomes of this regression.

The R square of the regression model is as high as in the first specification of the regression. The model has shown that membership in the EU does significantly boost bilateral trade between the countries. Despite a free trade area in the EU, the countries tend to trade with their traditional partners, which are close to them geographically and economically, or which are powerful economic leaders. The countries trade in accordance with their historical trading traditions. Membership in the EU or other trade unions may only intensify those trade bonds, which had been already built for years before. These trade patterns have not changed after the entrance of the countries to the EU. However, the amount of trade between these countries has grown. In other words, joining the EU in 2004 did not motivate the Czech Republic to diversify its foreign trade with all the European leaders, but it intensified its traditional trade relationship with Germany.

It is also important to differentiate between membership in the EU and membership in the Eurozone because of a range of reasons. Implementation of a single currency that must lead to the creation of an optimum currency area brings the following benefits for the countries-member. One of the biggest benefits is an intensification of trade. A lot of studies by economists have shown that the presence of borders between countries lowers international trade by 30%. It happens even if there are no serious trade limitations. It is related to the existence of different currencies in the countries (Alesina, Barro, and Tenreyro, 2003). The trade between countries is boosted since the transaction costs are lowered, and the exchange rate risks are minimised.

Therefore, membership in the EU has been replaced by a new variable – membership in the Eurozone. The R Square of the model is 0.9012, while the standard error is 0.8964, which makes it reliable. The coefficient for membership in the Eurozone was 0.1801. Therefore, the influence of this variable is even lower than for membership in the EU. Presence in the Euro area does not change the trade patterns of the countries significantly. Once again, presence in a union cannot change the trade character of a country, but it can intensify this trade with traditional

trade partners, which are regional gravity centres. Their ability to accumulate trade flows is mainly defined by their GDPs and distance.

6 Conclusions and Policy Suggestions

The research has shown that a gravity model remains a reliable and simple instrument which explains bilateral trade flows between countries. The main factors, which explain more than 90% of the variability of trade between countries, are the gross domestic product and distance. Despite the development of transport infrastructure and globalisation, distance remains a determinative factor of international trade. Adding other factors to the model can provide some additional reasoning but not change the overall regression. The possibility of the omitted variable bias in such a model is close to the minimum.

The gross domestic product of countries may be decomposed into GDP per capita and the population. These two variables represent the income effect and the quantitative effect (the size of the market). The regression has shown that the overall size of the market is more important than GDP per capita. Generally, a country with a high population and GDP per capita becomes a regional trade centre, which concentrates the majority of trade flows in the region. The regional trade leaders in Europe are the most powerful national economies. The geographical structure of the CEE countries' trade is highly concentrated, with the domination of these trade centres. It should be recommended to conduct a trade policy that would lead to broader diversification of the trade flows.

The existence of the EU and similar trade unions should have minimised the influence of single trade centres and provided an equal allocation of trade flows inside a region. The regression analysis has shown that trade unions cannot significantly change the trade traditions of the countries. They can only intensify trade relationships with traditional partners. On the other hand, the existence of the EU is justified in terms of international trade since all the countries from Central and Eastern Europe trade preferably with major European economies. In turn, these countries do not trade a lot with each other. That is why there is no possibility of creating some smaller trade blocks within the borders of the mentioned groups. Trade policies of the CEE countries should be relocated on the growth of trade within the smaller regional trade blocks, where the degree of competition is lower. Additionally, it will lead to the creation of industrial clusters and product

agglomerations. It will be easier for the CEE countries to protect their interests in European markets via common representation of each other as a member of a smaller regional block. Such trade defragmentation within the EU can be considered as diversification and minimisation of trade risks.

The CEE countries' product structure of export-import operations is characterised by a high degree of concentration. The product structure of a country's export can define the character of its foreign trade. The presence of high-value-added products in a country's export makes it more attractive for regional trade centres and increases revenues from international trade. Since all the countries of the region are highly industrialised states, the countries with the most powerful national economies become regional trade centres.

Common past and common borders between the CEE countries do not change their trade orientation to the regional trade leaders. The CEE countries do not develop product agglomeration with their closest neighbours and do not target their trade flows in these states. In such cases, these countries lose potential competitive advantages reached via the minimisation of transport costs. It is essential to develop cooperation and bilateral trade with the closest neighbours.

References

Alesina, A., Barro, R. and Tenreyro, S. (2003) Optimal Currency Areas. In: Rogoff, K., Gertler, M. (Ed.) NBER Macroeconomics Annual 2002, 17, p. 301–56 (MIT Press), available at: https://www.nber.org/books-and-chapters/nber-macroeconomics-annual-2002-volume-17.

Anderson, J.E. (1979) A Theoretical Foundation for the Gravity Equation, The American Economic Review, 69(1), p. 106-116.

Anderson, J.E., Van Wincoop, E. (2003) Gravity with Gravitas: A Solution to the Border Puzzle, American Economic Review, 93(1), p. 170-192.

Assaf, A., Bird, R., Garlaschelli, D. (2019) Enhanced Gravity Model of Trade: Reconciling Macroeconomic and Network Models, Frontiers in Physics, https://doi.org/10.3389/fphy.2019.00055.

Babecka Kucharcukova, O., Babecky, J., Raiser, M. (2012) Gravity Approach for Modelling International Trade in South-Eastern Europe and the Commonwealth of Independent States: The Role of Geography, Policy and Institutions, Open Economies Review, 23, p. 277–301.

Babetskaia-Kukharchuk, O., Maurel, M. (2004) Russia's accession to the WTO: the potential for trade increase, Journal of Comparative Economics, 32(4), p. 680-699.

Baier, S., Standaert, S. (2020) Gravity Models and Empirical Trade, Oxford Research Encyclopedias of Economics and Finance, https://doi.org/10.1093/acrefore/9780190625979.013.327.

Barbero, J., De Lucio, J.J. (2021) Effects of COVID-19 on Trade Flows: Measuring Their Impact through Government Policy Responses, PLoS One, 16, No. 10, https://doi.org/https://doi.org/10.1371%2Fjournal.pone.0258356.

Chaney, T. (2013) The Gravity Equation in International Trade: An Explanation. Working Paper No. 19285 (Cambridge: National Bureau of Economic Research), available at: https://www.nber.org/system/files/working_papers/w19285/w19285.pdf.

Chit, M.M., *et al.* (2010) Exchange Rate Volatility and Exports: New Empirical Evidence from the Emerging East Asian Economies, World Economy, 33(2), p. 239-263.

Cieślik, A. (2009) Bilateral trade volumes, the gravity equation and factor proportions, The Journal of International Trade & Economic Development, Taylor & Francis Journals, 18(1), p. 37-59.

Cipollina, M., Slavatici, L. (2010) Reciprocal Trade Agreements in Gravity Models: A Meta-Analysis, Review of International Economics, 18(1), p. 63-80.

De Benedictis, L., Taglioni, D. (2010) The Gravity Model in International Trade, chapter 4. In: De Benedictis, L., Salvatici, L. (Ed.) The Trade Impact of European Union Preferential Policies (Springer).

Deardorff, A. (1998) Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?, The Regionalization of the World Economy (National Bureau of Economic Research), p. 7-32.

Erginbay, U., Jindřichovská, I. (2022) Effect of COVID-19 on International Trade among the Visegrad Countries, Journal of Risk and Financial Management, 15(2), p. 1–2.

Evenett, S., Keller, W. (2002) On Theories Explaining the Success of the Gravity Equation, Journal of Political Economy, 2002, 110(2), p. 281-316.

Felbermayr, G., Toubal, F. (2010) Cultural proximity and trade, European Economic Review, 54(2), p. 279-293.

Frankel, J., Rose, A.K. (2002) An Estimate of the Effect of Common Currencies on Trade and Income, The Quarterly Journal of Economics, 117(2), p. 437-466.

Frankel, J., Wei, S. (1993) Emerging Currency Blocs, NBER Working Papers No. 4335 (National Bureau of Economic Research, Inc).

Geetha, R., Stack, M. (2014) The Gravity Model and Trade Efficiency: A Stochastic Frontier Analysis of Eastern European Countries' Potential Trade, World Economy 37, 5, https://doi.org/http://dx.doi.org/10.1111/twec.12144.

Harrigan, J. (1993) OECD imports and trade barriers in 1983, Journal of International Economics, 35(1-2), p. 91-111.

Helpman, E. and Krugman, P. (1985) Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy (Cambridge: MIT Press).

Kordalska, A., Olczyk, M. (2019) Is Germany a Hub of Factory Europe for CEE Countries? The Sink Approach in GVC Decomposition PDF Logo, GUT FME Working Paper Series A, No. 4/2019 (56).

Lizardo, R.A. (2009) Exchange rate volatility in Latin American and the Caribbean region: Evidence from 1985 to 2005, The Journal of International Trade & Economic Development, 18, p. 255 - 273.

Martínez-Zarzoso, I., *et al.* (2009), Does German Development Aid Promote German Exports?, German Economic Review 10(3).

Matyas, L. (2002) Proper Econometric Specification of the Gravity Model, The World Economy, 20(3), p. 363–68.

Munisamy, G., Feras A. Batarseh, Beckman, J. (2020) Machine Learning in Gravity Models: An Application to Agricultural Trade, Working Paper No. 27151 (Cambridge: National Bureau of Economic Research), available at: https://www.nber.org/papers/w27151.

Novy, D. (2010) Trade Costs and the Open Macroeconomy, The Scandinavian Journal of Economics, 112(3), p. 514-545.

OECD. (2001) CENTRAL and EASTERN EUROPEAN COUNTRIES (CEECS), Glossary of Statistical Terms, available at: https://stats.oecd.org/glossary/detail.asp?ID=303.

Rose, A.K. (2000) One money, one market: the effect of common currencies on trade, Economic Policy, 15(30), p. 8–45.

Schiff, M., Winters, L.A. (2003) Regional Integration and Development (Washington: World Bank and Oxford University Press).

Shahriar, S., Qian, L. (2019) The Gravity Model of Trade: A Theoretical Perspective. Review of Innovation and Competitiveness: A Journal of Economic and Social Research, 5(1), p. 21–42.
Spies, J., Marques, H. (2009) Trade effects of the Europe agreements: A theory-based gravity approach, The Journal of International Trade & Economic Development, 18(1), p. 11-35.
Subramanian, A., Wei S. (2003) The WTO Promotes Trade, Strongly But Unevenly, NBER Working Papers No. 10024 (National Bureau of Economic Research, Inc).
Tadesse, B., White, R. (2010) Cultural distance as a determinant of bilateral trade flows: do immigrants counter the effect of cultural differences?, Applied Economics Letters, 17(2), p. 147-152.
Wanjala Musila, J., Sigué, S.P. (2010) Corruption and International Trade: An Empirical Investigation of African Countries, The World Economy, 33(1), p. 129-146.
Whalley, J., Xin, X. (2009) Home and regional biases and border effects in Armington type models, Economic Modelling, Elsevier, 26(2), p. 309-319.

Appendix

Table 1: Components of the gravity equation in the research paper

α	The gravity constant
Trade	Overall trade between countries
Yi and Yj	GDP per capita of both countries, respectively
Pi and Pj	Number of population of both countries
Dij	Distance between countries
Ei	The share of value-added export in the overall export
EU	Dummy variable, which represents membership in the EU
CP	Dummy variable, which reflects the presence of a common past between countries
ε	Stochastic error

Table 2: The shares of imports and exports in the countries' GDP as of 2018, %

Country Name	Import	Export	Country Name	Import	Export
Slovak Republic	92,04241	92,43684	Bulgaria	60,9809	64,19163
Slovenia	75,28434	83,74322	Latvia	60,96625	60,12825
Hungary	79,06955	82,18818	Poland	50,82855	55,53525
Lithuania	72,24189	77,4512	Croatia	52,20992	51,96107
Czech Republic	68,36535	74,39082	Romania	44,2086	40,35127
Estonia	68,8972	72,90882	Albania	45,33594	31,55555

Source: calculated by the author, using the World Bank data from https://data.worldbank.org/indicator

Table 3: The CEE countries' shares in the global export as of 2018, %

Country	Poland	Czech Republic	Hungary	Romania	Slovak Republic	Slovenia
Export	1,46	0,91	0,62	0,5	0,43	0,23
Country	Bulgaria	Lithuania	Croatia	Latvia	Estonia	Albania
Export	0,2	0,18	0,15	0,13	0,11	0,03

Source: calculated by the author, using the World Bank data from https://data.worldbank.org/indicator

Table 4: The main macroeconomic indicators of the CEE countries

	2019	1996-2019
The average pace of GDP growth, %	3.44	3.42
The average GDP per capita, USD	17 221.65	12 344.50
The average unemployment, %	5.18	10.23
The average inflation, %	2.44	9.66

Source: calculated by the author, using the World Bank data from https://data.worldbank.org/indicator

Table 5: The main trading partners of the CEE countries as of 2018

	Exports		Imports	
	Partner	Share, %	Partner	Share, %
Estonia	Finland	15.13	Germany	9.95
Latvia	Lithuania	17.13	Lithuania	17.40
Lithuania	Russian Federation	14.00	Russian Federation	14.17
Poland	Germany	28.15	Germany	22.40
Hungary	Germany	27.27	Germany	25.95
Czech Republic	Germany	32.41	Germany	25.08
Slovakia	Germany	22.17	Germany	18.08
Slovenia	Germany	20.30	Germany	16.29
Bulgaria	Germany	14.59	Germany	12.37
Romania	Germany	22.97	Germany	20.46
Croatia	Germany	14.59	Germany	15.25
Albania	Italy	48.03	Italy	27.33

Source: World Integrated Trade Solutions by the World Bank https://wits.worldbank.org/

Table 6: Regression statistics 1

Regression statistics	
Multiple R	0,956704575
R Square	0,915283644
Adjusted R Square	0,913092704
Standard Error	0,680701173
Observations	120

Table 7: Regression coefficients 1

	Coefficients	Standard Error	t-Stat	P-value
Intercept	-1,8379	0,9876	-1,8609	6,53%
Log(GDP1)	0,9165	0,0510	17,9700	0,00%
Log(GDP2)	0,8837	0,0345	25,6116	0,00%
Log(Distance)	-1,7784	0,1066	-16,6902	0,00%

Table 8: Regression statistics 2

Regression statistics	
Multiple R	0,940847865
R Square	0,885194705
Adjusted R Square	0,884944494
Standard Error	0,966211725
Observations	2760

Table 9: Regression coefficients 2

	Coefficients	Standard Error	t-Stat	P-value
Intercept	-28,3284	0,4654	-60,8683	0,0000%
LnYi	0,8967	0,0309	29,0394	0,0000%
LnYj	0,6975	0,0250	27,8795	0,0000%
LnPi	0,9300	0,0170	54,6283	0,0000%
LnPj	0,9196	0,0123	74,6798	0,0000%
LnD	-1,8543	0,0320	-57,9459	0,0000%
LnEi	0,7201	0,0707	10,1905	0,0000%

Table 10: Regression statistics 3

Regression statistics	
Multiple R	0,950705222
R Square	0,903840419
Adjusted R Square	0,903560784
Standard Error	0,884596945
Observations	2760

Table 11: Regression coefficients 3

	Coefficients	Standard Error	t-Stat	P-value
Intercept	-30,4705	0,4673	-65,2009	0,0000%
LnYi	0,7570	0,0301	25,1576	0,0000%
LnYj	0,7162	0,0256	27,9501	0,0000%
LnPi	1,0495	0,0164	63,8314	0,0000%
LnPj	0,9266	0,0117	79,1429	0,0000%
LnD	-1,6400	0,0309	-53,0345	0,0000%
LnEi	0,5600	0,0657	8,5284	0,0000%
EU	0,4293	0,0476	9,0224	0,0000%
CP	0,9367	0,0445	21,0458	0,0000%