BUILDING GRAVITY MODELS OF INTERNATIONAL TRADE USING THE WOLFRAM MATHEMATICA PACKAGE

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This article is devoted to building gravity models of international trade and studying of their practical opportunities. During the research were built three models: Belarus – Russia, Belarus – Ukraine and Belarus – China. This models show interdependence of trade between Republic of Belarus and its main trade partners from GDP and population. A conclusion was made that foreign trade turnover of the above-named couples of countries really depends on changes in GDP and population, dependence degree in three models is different and changes from an indicator to an indicator. All calculations were made in Wolfram Mathematica system. It is the package of symbolical mathematics with the highest speed and accuracy.

Key words: international trade; gravity models; Linneman's model; Wolfram Mathematica; practical implementation of Mathematica package.

The foreign trade turnover, which is in direct dependence on economic capacity of the trading countries and in the return from distance between them, acts as the main idea of gravity model of international trade. The distance between partners is reflected first of all in trade costs which grow with increase in distance between countries. One of the most often used are models of the Dutch economist, the first Nobel Prize laureate on economy (1969) Jan Tinbergen and model of famous professor and expert in the field of economy Hans Linneman in whose work for the first time was added the regressor – the population of the country [1].

BELARUS – RUSSIA MODEL

At the moment Belarus maintains trade relations with more than 200 countries of the world. The main trade partner for Republic of Belarus is the Russian Federation: in 2018 the share of Russia in the total amount of turnover of Belarus was 49.5 %, and in 2017 – 51.1 %. It shows not only the importance of the Russian Federation as trade partner, but also about close interrelation of two economic systems. Development of mutually beneficial cooperation is one of the main purposes of creation of the Union State of Russia and Belarus. Let's consider how internal factors can influence a foreign trade turnover of two countries.

For the analysis we will use the simplified Linneman's model in an exponential form:

$$X_{ij} = a_0 \times (Y_i)^{a_1} \times (Y_j)^{a_2} \times (N_i)^{a_3} \times (N_j)^{a_4} + \varepsilon,$$

where X_{ij} is the size of turnover between the countries; Y_i and Y_j – GDP of Belarus and Russia respectively in the current prices; N_i and N_j – the population of the countries for the beginning of year; a_1, a_2, a_3, a_4 – elasticity coefficients of export respectively from GDP of the export country or GDP of the import country, population of the countries; a_0 – the intercept term; ε – a random error [2].

One of potential scopes of gravity models of foreign trade is the explanation and forecasting of volumes of trade flows. It is possible to predict future volumes of turnover or to explain existing, proceeding from the available data after obtaining required coefficients of elasticity and having the reasonable assumptions of change in the short or long-term period of some variables of the equation. So, to build model we will use the data provided in table 1.

Table 1

Input data for Belarus-Russia gravity model

Year	Trade between BLR and RUS, bln. US $	GDP of BLR, bln. US $	GDP of RUS, bln. US $	Population of BLR, mln.	Population of RUS, mln.
2013	39.7424	75.528	2297.128	9.464	143.3
2014	37.3712	78.814	2063.663	9.468	143.7
2015	27.5416	56.455	1363.705	9.481	146.3
2016	26.2548	47.749	1282.664	9.498	146.5
2017	32.4934	54.456	1578.417	9.505	146.8

Further we pass to building model in the Wolfram Mathematica [3] program. At first we set an input interval in a matrix form, we define the database by the data procedure, then we build model by means of the NonlinearModelFit function [4]:

data={{75.528, 2297.128, 9.464, 143.3, 39.7424}, {78.814, 2063.663, 9.468, 143,7, 37.3712}, {56.455, 1363.705, 9.481, 146.3, 27.5416}, {47.749, 1282.664, 9.498, 146.5, 26.2548}, {54.456, 1578.417, 9.505, 146.8, 32.4934}};

soln=NonlinearModelFit[data,$k * x^n * y^m * z^u * h^l$, $\{k, n, m, u, l\}, \{x, y, z, h\}$, MaxIterations$\rightarrow$ 1000].

Among arguments of function the entrance interval, a general view of function defined variables $\{k, n, m, u, l\}$ and the defining variables $\{x, y, z, h\}$. In addition, we set MaxIterations$\rightarrow$1000 parameter [5] determining the maximum number of attempts of selection of coefficients necessary for us.

After implementation of commands we receive result:

Out[1]=FittedModel [$8.4676 \times h^{4.98296} x^{0.0256766} y^{0.887841} z^{0.919041}$].

Economic interpretation of this model allows to draw the following conclusions: at increase in GDP of Republic of Belarus by 1 %, turnover between

R-B will increase by 0.0257 %, and at increase in GDP of the Russian Federation by 1 % turnover between the countries will increase by 0.888 %. At the same time increase in the population will also affect a foreign trade turnover of the countries: at increase in the population of Belarus by 1 %, commodity turnover will increase by 0.919 %, and at similar change in Russia, commodity turnover will increase by 4.98 %. Certainly, considering a huge difference in indicators of the population and GDP, it is clear that 1 % change of these values in Russia will cause bigger effect, than similar change in Republic of Belarus. However, and it takes place to be, model tells both interrelations of economies, and importance of trade cooperation of Belarus and Russia.

BELARUS – UKRAINE MODEL

The second largest trade partner of Republic of Belarus is Ukraine. So in 2017 the share of Ukraine in the total amount of the foreign trade turnover made 7.3 %, and in 2018 increased by 0.3 % and made 7.6 %, in terms of money – 5464.7 million US dollars.

When constructing gravity model of international trade for Ukraine and Belarus, it is possible to draw the following conclusions: at increase in GDP of Ukraine by 1 % turnover between the countries will increase by 1.13 %. Increase in the population is capable to influence a foreign trade turnover of the countries too: at increase in the population of Belarus by 1 %, commodity turnover will decrease by 0.865 %, and at similar change in Ukraine, commodity turnover will decrease by 4.587 %. Therefore, as well as in a case with the Russian Federation, 1 % change in indicators of Ukraine is capable to cause bigger change of size of turnover between the countries, than change of indicators of RB. The received answer allows to draw the general conclusion on existence of interrelation between changes of GDP and population and size of merchandise turnover between the countries.

BELARUS – CHINA MODEL

The third trade partner of Belarus is People's Republic of China: in 2017 the commodity turnover share in total amount made 5.0 %, and in 2018 – 5.1 % or 3677.6 million US dollars.

We pass directly to a settlement part. As well as in case of creation of the previous models, we set the entrance data through the data function, then we use the soln and NonlinearModelFit procedures for a task of a general view of model and definition of the known variables and required coefficients of elasticity, in addition we include in team: MaxIterations→1000, – determining the maximum number of attempts of selection of necessary coefficients.

The answer allows to estimate interdependence of turnover of China and Belarus at the points of view of 1 % change of GDP or population of one or

second country. For example, at corresponding change of GDP of China, commodity turnover with Republic of Belarus will decrease by 0.62 %. All received coefficients say that commodity turnover of the countries depends on the chosen indicators and between economies there is a communication.

CONCLUSION

On the basis of the received theoretical skills were built the gravitational models of international trade based on real data. The impact of changes of some economic and socio-economic indexes on turnover between couples of the countries was studied. The foreign trade turnover of the above-named couples of countries really depends on changes in GDP and population, dependence degree in three models different and changes from an indicator to an indicator. It can be explained by remoteness of the countries from each other, different structures of import and export and also various national peculiarities.

It is necessary to say about the high practical importance of use of the Wolfram Mathematica system in the economic sphere. Besides, the Mathematica package is useful at a training stage as it provides a set of additional functions, contains hints about the made mistakes and is capable of showing step-by-step solution of difficult functions.

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