Estimating the Consequences of Russia's and the EU's Sanctions Based on OLS Algorithm

I. V. Tregub and K. A. Dremva

Abstract— **In the presented paper, financial analysis of the consequences of sanctions imposed by the European Union on Russian Federation and Russian counter-sanctions was carried out. With the application of the OLS algorithm, an econometric model was developed. The key factors, which influence the growth of the EU economy, have been identified. It was shown how exactly the EU would proceed after having severed or at least severely restricted its trade turnover with Russia. As it is showcased in the model, the EU is not particularly dependent on its ties with Russia in order to continue flourishing. Throughout this research, we have obtained a model, which best highlights the connection formed between Russia and the EU via studying the links between the aggregate GDP of the EU and the values for the export to Russia and import from Russia, as well as the price for gas, as the EU is the primary consumer of the Russian gas resources.**

Index Terms—**Computing, econometric model, Russia's and the EU's sanctions.**

I. Introduction

In the early twenty-first century, as well as in the twentieth century, economic sanctions remain important (although double-edged) instrument of foreign policy and international diplomacy. Imposed for a limited time, they can have a lasting effect, and an economy cannot feel fully their effect immediately, but after some time. A negative impact (decrease in the growth rate of GDP, loss of jobs and opportunities for the development of the business sector, etc.) appear with "a time lag". In addition, the sanctions are abolished not always as fast as they are introduced.

For example, the Jackson-Vanik amendment to the Trade Act of the United States, which was adopted in 1974 during the Cold War because of the restrictions on emigration of people from the USSR, was revoked in respect of Russia, as the legal successor of the Soviet Union, only in 2012, although emigration from the USSR was authorized in 1987.

The researchers from Peterson Institute for International Economics (PIIE) in their book "Economic Sanctions Reconsidered: History and Current Policy" [1] came to the conclusion that sanctions could achieve their aim in one-third of more than hundred cases. Despite dramatic changes in the world over the past quarter of the century, the main conclusions of the authors of the book remain relevant today.

The costs of sanctions for the country's economy, which takes the decision on their introduction, almost never can be calculated beforehand. First, to estimate these values is very difficult. Secondly, as Hufbauer G.C. wrote in his work, the damage to major economies, which impose sanctions, is insignificant and usually does not exceed 1% of GNP. However, if annual GDP growth amounts for approximately 1% or more, like in the EU and Russia, the introduction of sanctions may lead to negative dynamics of the growth for both sides.

The economy of imposing sanctions country tends to be much larger than the other country. For comparison: according to the World Bank (see Fig. 1), Russia (based on the current exchange rate) accounts for 1,8% of world GDP and the EU — 22%. It is obvious that the most vulnerable side is the less powerful economy. In our case, Russia bears the losses from the sanctions, began in 2014, more than the EU.

Nevertheless, the Russian retaliatory measures in the form of an embargo on the import of certain food products, which can be counted as over 12 billion euros of loss within the trade with Russia, amounts for less than 1% of total EU exports [2]. Compared to the EU's GDP, this value is rather small, but for individual countries, such as Poland, Hungary, Finland, Lithuania, the negative effects of Russian sanctions are fairly appreciable, and the European Union attempts to prevent deliveries of sanctioned products to Russia from countries of Latin America and Asia.

Consequently, at this point, it is very difficult to conclude that Russian contra-sanctions are not considered for the European economy at all. Therefore, in this work, we would like to analyze negative impacts of sanctions and contra-sanctions of Russia on the European Union's economy and to identify the most valuable indicators, which influence the EU's GDP for constructing a reliable econometric model.

To our mind, to understand whether these measures, introduced by the EU and Russia, are effective or not and what are the consequences, it is necessary to overview a brief history of EU-Russian relationship, sanctions and contra-sanctions, which will be considered further in my work and then give a description of the EU's economic system.

II. Economic System of European Union

A. EU-Russian Trade Relationship

Russian Federation and the European Union engage in active political dialogue and jointly fight against international organized crime and terrorism, which makes their relationship, be a strategic partnership. The cooperation of

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Russia and the EU is based on the Agreement on partnership and cooperation (signed on 24 June 1994 and entered into force on December 1, 1997), which is the most comprehensive document in the international contract practices of both sides.

Without any doubt, the European Union and Russia are significantly important economic partners. However, the dependence of the national economy on the partner's economy is different. The EU is the first trading partner of Russia, as you can observe in Fig. 2, while Russia is only the third trading partner of the EU, mainly due to the dependence on the supply of natural gas.

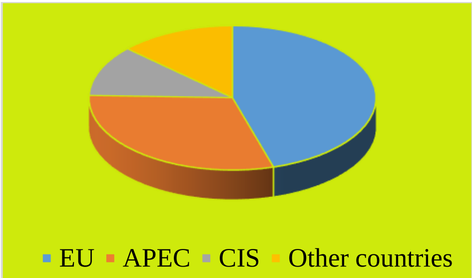

Fig. 1. Geographical structure of Russian foreign trade, 2017.

Regarding the structure of mutual trade, it is characterized by double asymmetry. Firstly, based on the data in January 2017 (see Fig. 1), the share of the countries-members of EU in the external trade of Russia is 45,40 %, whereas Russia's share in their imports and exports amounts to 7% and 4% accordingly (see Fig. 2). In other words, Russia takes the 4th place in the list of top trade partners. Secondly, the commodity structure of trade between Russia and the EU is also asymmetric [3]. Russia exports to Western Europe mainly energy and raw materials, mineral products, metal; and among manufactured goods: a limited range of relatively simple products and semi-finished products [4]. On the contrary, Russia imports mainly machinery, equipment, chemicals, medicine and many other consumer goods of mass and elite demand.

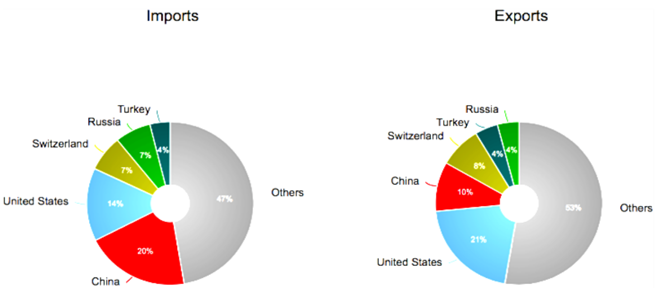

Fig. 2. Trade in goods by top five partners of the EU28, 2016.

This is a vivid confirmation of the idea of inequality in trade partnership. It leads to the unequal distribution of profits and losses among countries. Taking into consideration information, that was presented above, we would like to suggest the thesis that sanctions and contra-sanctions will not dramatically influence the main indicator of the European economy - GDP ($, current prices), but it does not mean that each country individually did not lose a huge amount of money from exports.

Also, the graph below (see Fig. 3) represents the dynamics of trade relations between the EU and Russia during the last five years (from the European Union, as it was taken from the Eurostat database). As we can observe, export and import reached its peak in 2012 and then started to fall sharply. The decrease of 2012-2014 years can be explained by the fall of RUB currency and worsening of the overall economic situation, and therefore, the fall of the value of imported gas, etc. As we have mentioned before, due to the high specialization of Russian trade, all these figures are quite "sensitive" to currency fluctuations [5]. But in this work, we are more interested in the falling numbers of export, import and trade balance since 2014, as they can be explained by sanctions and other political tools.

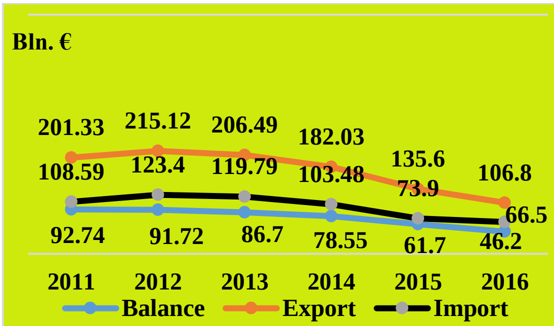

Fig. 3. Trade turnover between EU and Russia, 2011-2016.

Anyway, before the description of the European economic system, there is a necessity to remind about how these sanctions were imposed and what economic spheres they are connected with [6].

The formulation of the grounds for the imposition of economic sanctions in the official documents of the European Union, developed and published in connection with the policy of Russian Federation, was changing according to with the development of the conflict in Ukraine. First, sanctions were imposed as a reaction to "actions that undermine the territorial integrity, sovereignty, and independence of Ukraine or threaten them" (Council of the European Union, 2014a). This meant changing the status of Crimea.

Then, before the active phase of the conflict in the South-East of Ukraine, sanctions were imposed "in view of Russia's actions destabilizing the situation in Ukraine" (Council of the European Union, 2014b. P. 21-23; 2014c. P. 1-3). In September, it returned more stringent in its original wording of March 2014. This evolution appears to be associated with the escalation of the conflict in the Luhansk and Donetsk regions. Table I shows the EU economic sanctions against Russia and its retaliatory measures [7].

Immediately after the introduction of the main package (in 2014) of retaliatory sanctions, several economies, that were oriented on the Russian market, were "hit" the most:

- Iceland — about a third of the export of frozen fish;
- Belgium — about a quarter of the exports of apples;
- Poland — more than 50% of exports of apples;
- Estonia — almost 50% of fish exports and over one third of cheese;
- Lithuania — 50% of cheese exports and more than 40% of pork;
- Finland — about one-third of export of poultry and fish, 70% of butter, more than 75% cheese and 60% milk.

In fact, the initial damage was concentrated in countries with poorly developed (by the standards of the EU) economy, which was oriented to the export of agricultural products [8]. To partially reduce the negative impact, the EU has given farmers 280 million euros (for summer 2016). That is why statistical figures do not show a dramatic decrease in aggregate agricultural output. However, the agricultural sector is the only market in Europe where we can see the influence of Russia, mostly because retaliatory sanctions were focused on this economic sector. However, the question is, whether agriculture in several countries is so significant for the European economy that can reflect aggregate numbers, which are under our consideration? To answer this question, we ought to analyze the structure of the economic system of the European Union.

TABLE I: HISTORY OF SANCTIONS AND CONTRA-SANCTIONS (2014-2016)

Date	Who imposed sanctions?	What sanctions were imposed?
Stage 1: 17.03.2014	The USA, the EU, Australia, Canada, Norway, Albania, Iceland, Montenegro, Moldova, Ukraine	Visa sanctions Assets freeze in the USA
Stage 2: 28.04.2014	The USA, the EU EBRD	Visa sanctions
23.07.2014		End of new investment activities
Stage 3: 31.07.2014	The USA/the EU	Trade limitations
11.08.2014	Russia	Limitations on government purchases of foreign light industry products
12.09.2014	The USA	Sanctions on financial, energy and defense sectors Limited access to market of promissory notes in the USA
18.12.2014	The EU	Investments in Crimea Trade limitations
16.02.2015	The EU	Trade limitations Visa sanctions
1.01.2016	Russia	Limitations on agricultural products, raw materials and food, produced in Ukraine
1.07.2016	Russia	Embargo was extended to transit

B. *Description of Economic System*

The European Union is the world's most significant exporter and second largest importer. Trade between the member countries is not limited by tariffs and border controls. Having its own single currency, (a majority of member states operate with Euro) leads to simplification of internal trade. The European Union plays the role of representative of all its members in the World Trade Organization (known as WTO), and make decisions for them in case of any discussions. Moreover, the economic area of the European Union is the worldwide biggest and amounts for approximately 340 million people.

Basing on the counter-part of GDP of the whole world, EU’s economy takes third place after the United States of America and China. Similarly, to other well-developed economies, the service sector has the biggest share of overall output, before the industrial sector, while the share of agriculture, fishing, and forestry is rather limited. Considering more precisely, based on the estimations of CIA in 2016, the composition of GDP by sector is as follows: agriculture - 1.6%, industry - 24.4%, services – 71,3%. Taking into account the given basic structure of the European economy, it becomes obvious why sanctions, which are primarily connected with agriculture, do not significantly influence the European Union in a broad sense.

About the economic structures of members of the European Union, they vary within different European countries. This leads to differences in economic situations of member countries. Among factors, that influence these distinctions, are geographical location, specifics in laws and public policies of local governments, consumers’ preferences and demography, etc. Consequently, each member specializes in a unique sphere of the market, range of products, etc.

Without any doubt, the European Union, as a whole, is highly-oriented and specialized in trade with other countries all over the world. Many goods and services that are manufactured in the territory of the EU are sold internationally. Nevertheless, the dependence of each European country on international trade varies. That is why, some countries are damaged by sanctions more than others, due to the particular orientation of their national economy.

Indicators, such as Gross domestic product per capita, unemployment rate, CPI, inflation rate and other indicators, which primarily show prosperity of society and economy, show significant numbers (for instance, in 2016 inflation rate is only 1,1%, which in economic theory means that there is no sharp increase in prices and currency is stable).

Overall, the economic system of the European Union is a high-income and high-developed open market economy with a big share of government spending on social policy, massive investment flows, broadly developed trade policies, etc. The economy of the EU is characterized by a high degree of openness. The countries are thus dependent on international trade. Both export and import constitute great shares of GDP, so it is difficult to say that the economy is dependent on only export or import. Overall, the economy is quite balanced and has a reliable legislative basis. For constructing an econometric model, we will try to use indicators (variables), which explain clearly the components of European GDP, described above.

C. *The Primary Task of the Work*

The main aim of this work is to identify important indicators for GDP of the European Union; and whether indicators, connected with trade with Russia, are included or not. More generally, we would like to know the real consequences of sanctions against Russia and retaliatory sanctions, independently of what TV and mass media shows. In our opinion, it is rather essential for the future development of Russian economy to find ‘weak places’, or spheres, where trade partners are highly dependent on Russian supplies, and to use this knowledge while introducing new foreign policies. As we know from economic theory, the primary force of any market player is to get profit. Obviously, it is impossible not to take into account current political situation, but even having these strained relations with European Union, the USA, and other countries give opportunities to behave rationally in the market and have profit. The theme of this work is a very difficult issue, but we cannot deny its actuality, that is why, to our mind, such type of research is needed.

There are different opinions on the impact of sanctions on economies of the countries participating in the sanctions relationship. For the Russian economy under current conditions, there is an unquestionable benefit, which can be expressed as the development and strengthening of the processes of import substitution, especially in the agriculture sector. Contrary, it should be said that sanctions significantly decreased the level of welfare of the Russian population, which, no doubt, is a negative aspect. As can be seen from the information above, the losses of Russia in the war of sanctions are significant, and they also adversely affect the formation of budget revenues of the country.

Without any doubt, sanctions and retaliatory measures for the economy of the European Union decreased the amount of import and export. As noted by French researchers, the central part of the losses of the European Union (82 %) was due to European sanctions (but not Russian embargo). Experts conclude that this “collateral damage” can be explicated with the help of the fact that the financial penalties have led to problems with trade financing under export in the Russian Federation. However, economists write that losses from sanctions are more damaging in short-term for Russia (and numbers show it), but in the long-term period it is tough to forecast whether trade partners will manage to substitute products and find new customers or not.

From economic theory, we would like to highlight the Keynesian model [9] that can be used as a basis of this work. British economist John Keynes made a revolution in economics and suggested that free markets cannot guarantee full employment only by self-balancing [10]. Keynes believed that aggregate demand Y^D is the most significant driving force in an economy. Keynesian economics supposes that the market should operate with the help of government, which can be explained by policies and other tools to stabilize employment, prices of goods and services, etc. For Keynes, in conditions of open economy with government intervention, exogenous factors that influence growth domestic product Y (GDP) are consumption C, which stands for consumption, investment I, government spending G, export X and import I_m, as prices are somewhat rigid and fluctuations in any component of spending cause output to change. For instance, if government spending goes up and all other spending components remain constant, then the output will increase [11], [12]. In this work which we are interested in, as they are connected with trade with Russia) without primary exogenous factors. However, the Keynesian model does not include all possible exogenous factors and we will try to broaden their range and to calculate whether they are significant or not.

III. OLS Algorithm

A. Basics of Algorithm Description

In the analysis of economic phenomena based on economic and mathematical methods models, occupy a special place, revealing the quantitative relation between the studied parameters and factors influencing them. Scientific disciplines, the subject of which is the study of the quantitative aspects of economic phenomena and processes by means of mathematical and statistical analysis is econometrics, in which the results of the theoretical analysis of the economy are synthesized with the conclusions of mathematics and statistics. The main objective of econometrics - test economic theories on factual (empirical) material using methods of mathematical statistics.

The main tool of econometrics is the econometric model, i.e., economic-mathematical model of factor analysis, the parameters of which are estimated by means of mathematical statistics. This model serves as a tool for analysis and forecasting of specific economic processes based on real statistics.

Econometric models can be classified in a number of classifications. Thus, according to the analytical form of the model (equation) there can be linear, nonlinear, exponential models, and others.

Regression models based on the regression equation or a system of regression equations relating the values of endogenous and exogenous variables. There are equations (models) of pair and multiple regression. Interdependent system more fully describes the economic system, containing, as a rule, a plurality of interconnected endogenous and exogenous variables. Such models are given a system of interdependent equations of the following form:

$$y_1 = a_{10} + a_{11} x_1 + \ldots + a_{1m} x_m + b_{12} y_2 + \ldots + b_{1n} y_n ;$$
$$y_2 = a_{20} + a_{22} x_2 + \ldots + a_{2m} x_m + b_{22} y_2 + \ldots + b_{2n} y_n ;$$
$$. \quad .$$
$$y_n = a_{n0} + a_{n1} x_1 + \ldots + a_{nm} x_m + b_{n2} y_2 + \ldots + b_{nn-1} y_{n-1}.$$

To determine the parameters of the system of interdependent equations used more sophisticated techniques: two- and three-step method of least squares, maximum likelihood methods with complete and incomplete information, and others. In the case, there is only one equation in the model contains it is permissible to apply an ordinary least-squares method, abbreviated OLS.

The method of least squares (Ordinary Least Squares, OLS.) is a mathematical algorithm used to solve various tasks, based on minimizing the sum of squared deviations of certain functions of the unknown variables. It can be used for "solution" of predetermined systems of equations (when the number of equations exceeds the number of unknowns), to find a solution in the case of conventional (not redefined) of non-linear systems of equations to approximate the point values of a function.

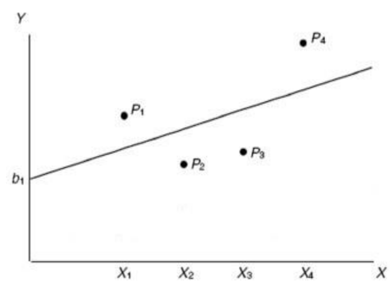

Fig. 4. Linear equation and observations (without residuals).

Suppose that we are given the four observations on independed variable X and depended variable Y represented in Fig. 4 and we are asked to obtain estimates of the values of β_1 and β_2 in equation

As a rough approximation, you could do this by plotting the four P points and drawing a line to fit them as best you can. (as it is done in figure)

The intersection of the line with the Y-axis provides an estimate of the intercept β_1, which will be denoted b_1, and the slope provides an estimate of the slope coefficient β_2, which will be denoted b_2 [13], [14].

The fitted line will be written:

$$\hat{Y} = b_1 + b_2 X_i \ , \tag{1}$$

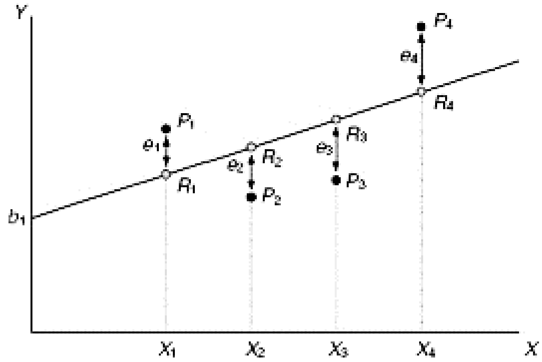

Fig. 5. Linear equation and observations (with residuals).

The caret mark over depended variable Y indicating that it is the fitted value of Y corresponding to independed variable X, not the actual value.

In Fig. 5, the fitted points are represented by the points $R_1, \ldots, R_4$. Coefficients b_1 and b_2 are only estimates, and they may be good or bad.

For calculating good estimates of β_1 and β_2 several actions should be done.

The first step is to define what is known as a residual for each observation. This is the difference between the actual value of depended variable Y in any observation and the fitted value given by the regression line, that is, the vertical distance between points P_i and R_i in observation i.

It will be denoted as e_i:

$$e_i = Y_i - \hat{Y}_i, \tag{2}$$

Combining

$$e_i = Y_i - \hat{Y}_i \text{ and } \hat{Y} = b_1 + b_2 X_i$$

we obtain:

$$e_i = Y_i - b_1 - b_2 X_i, \tag{3}$$

and hence the residual in each observation depends on our choice of coefficients b_1 and b_2.

Obviously, we wish to fit the regression line, that is, choose b_1 and b_2, in such a way as to make the residuals as small as possible.

One way of overcoming the problem is to minimize the sum of the squares of the residuals or RSS.

In our case

$$RSS = e_1^2 + e_2^2 + e_3^2 + e_4^2 \ , \tag{4}$$

If one could reduce RSS to 0, one would have perfect fit, for this would imply that all the residuals are equal to 0. The line would go through all the points, but of course, in general the disturbance term makes this impossible.

Least Squares Regression with one explanatory variable.

We shall now consider the general case where there are n observations on two variables X and Y and, supposing Y to depend on X, we will fit the equation

$$\hat{Y} = b_1 + b_2 X_i, \tag{5}$$

The fitted value of the dependent variable in observation with number i

$$\hat{Y}_i \text{, will be } (b_1 + b_2 X_i) \tag{6}$$

And the residual e_i will be

$$e_i = (Y_i - b_1 - b_2 X_i), \tag{7}$$

We wish to choose b1 and b2 so as to minimize the residual sum of the squares, RSS, given by

$$RSS = e_1^2 + \cdots + e_n^2 = \sum_{i=1}^{n} e_i^2, \tag{8}$$

We shall assume that the true model is

$$Y_i = \beta_1 + \beta_2 X_i + u_i, \tag{9}$$

and we shall estimate the coefficients b_1 and b_2 of the equation

$$\hat{Y}_i = b_1 + b_2 X_i \ , \tag{10}$$

Now we want to choose b1 and b2 to minimize RSS. To do this, we calculate the partial derivative and find the values of b_1 and b_2 that satisfy

$$\frac{\partial \ RSS}{\partial b_1} = 0 \tag{11}$$

$$\frac{\partial \ RSS}{\partial b_2} = 0 \ , \tag{12}$$

We will begin by expressing the square of the residual in observation i in terms of b_1, b_2, and the data on X and Y:

$$e_i^2 = (Y_i - \hat{Y}_i)^2 = (Y_i - b_1 - b_2 X_i)^2 = Y_i^2 + b_1^2 + b_2^2 X_i^2 - \\ - 2b_1 Y_i - 2b_2 X_i Y_i + 2b_1 b_2 X_i, \tag{13}$$

Combining expressions we can write RSS as

$$RSS = (Y_1 - b_1 - b_2 X_1)^2 + \cdots + (Y_n - b_1 - b_2 X_n)^2 = \\ = Y_1^2 + b_1^2 + b_2^2 - 2b_1 Y_1 - 2b_2 X_1 Y_1 + 2b_2 b_2 X_1 + \cdots + \\ + Y_n^2 + b_1^2 + b_2^2 X_n^2 - 2b_1 Y_n - 2b_2 X_n Y_n + 2b_1 b_2 X_n = \\ = \sum_{i=1}^{n} Y_i^2 + n b_1^2 + b_2^2 \sum_{i=1}^{n} X_i^2 - 2b_1 \sum_{i=1}^{n} Y_i - \\ - 2b_2 \sum_{i=1}^{n} X_i Y_i + 2\, b_1 b_2 \sum_{i=1}^{n} Y_i \ , \tag{14}$$

Note that RSS is effectively a quadratic expression in coefficients estimations b_1 and b_2, with numerical coefficients determined by the data on variables *X* and *Y* in the sample.

We can influence the size of RSS only through our choice of b_1 and b_2.

The data on *X* and *Y*, which determine the locations of the observations in the scatter diagram, are fixed once we have taken the sample.

The first order conditions for a minimum is given by formulas (11) and (12), yield the following equations:

$$2nb_1 - 2\sum_{i=1}^{n} Y_i + 2b_2 \sum_{i=1}^{n} X_i = 0, \quad (15)$$

$$2b_2 \sum_{i=1}^{n} X_i^2 - 2\sum_{i=1}^{n} X_i Y_i + 2b_1 \sum_{i=1}^{n} X_i = 0, \quad (16)$$

These system of equations are known as the normal equations for the regression coefficients.

Equations (15) and (16) allow us to write b_1 in terms of mathematical expectation of an independent variable $\bar{X}$ and mathematical expectation of a dependent variable $\bar{Y}$ yet unknown b_2, where

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i , \quad (17)$$

and

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i, \quad (18)$$

$$2nb_1 - 2n\bar{Y} + 2b_2 n\bar{X} = 0, \quad (19)$$

$$b_1 = \bar{Y} - b_2\bar{X}, \quad (20)$$

$$\sum_{i=1}^{n} X_i = n\bar{X}, \quad (21)$$

$$2b_2 \sum_{i=1}^{n} X_i^2 - 2\sum_{i=1}^{n} X_i Y_i + 2(\bar{Y} - b_2\bar{X})n\bar{X} = 0, \quad (22)$$

Separating the terms involving b_2 and not involving b_2 on opposite sides of the equation, we have

$$2b_2 \sum_{i=1}^{n} X_i^2 - 2\sum_{i=1}^{n} X_i Y_i + 2(\bar{Y} - b_2\bar{X})n\bar{X} = 0, \quad (23)$$

Dividing both sides in the equation (23) by double the number of observations 2n we have

$$\left[\frac{1}{n}\left(\sum_{i=1}^{n} X_i^2\right) - \overline{X^2}\right] b_2 = \frac{1}{\mathrm{n}}\left(\sum_{i=1}^{n} X_i Y_i\right) - \overline{XY} , \quad (24)$$

Using the alternative expressions for sample variance and covariance, this may be rewritten as

$$b_2 Var(X) = Cov(X,Y) \text{ and so, } b_2 = \frac{\mathrm{Cov(X,Y)}}{\mathrm{Var(X)}}, \quad (25)$$

We have found that RSS is minimized when

$$b_2 = \frac{\frac{1}{n}\left(\sum_{i=1}^{n} X_i Y_i\right) - \overline{XY}}{\left[\frac{1}{n}\left(\sum_{i=1}^{n} X_i^2\right) - \overline{X^2}\right]}, \quad (26)$$

$$\sum_{i=1}^{n} X_i = n\bar{X} , \quad (27)$$

$$b_2 = \frac{Cov(X,Y)}{Var(X)}, \quad (28)$$

$$b_1 = \bar{Y} - b_2\bar{X} , \quad (29)$$

B. Interpretation of a Linear Regression Equation

A foolproof way of interpreting the coefficients of a linear regression (1) when *Y* and *X* are variables with straightforward natural units (not logarithms or other functions).

The first step is to say that a one-unit increase in *X* (measured in units of *X*) will cause a b2 unit increase in *Y* (measured in units of *Y*).

The second step is to check to see what the units of *X* and *Y* actually are, and to replace the word "unit" with the actual unit of measurement.

The third step is to see whether the result could be expressed in a better way, without altering its substance.

The constant, b_1, gives the predicted value of *Y* (in units of *Y*) for *X* equal to 0. It may or may not have a plausible meaning, depending on the context.

C. OLS Algorithm for Analyzing the Consequences of Sanctions

In econometrics, OLS is used to estimate the coefficients of the regression model. Model specification is the process of creating a regression model, which consists of choice of an appropriate functional form for the model and selecting of proper variables.

Firstly, a regression equation from endogenous and exogenous variables should be created. According to the first principle of specification, the model will be in the form of linear equation. Therefore, the functional relationship between one independent variable and nine independent variables would be as follows: $Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9)$.

All the variables are dated (the third principle). And based on the fourth principle, there is a disturbance term ε, which include all other variables that are not utilized in the model but have any influence. Furthermore, the first Gauss-Markov condition states that equation

$$E(\varepsilon_t)=0$$

should be included into the model, which means that the expected value of the disturbance term in any observation should equal zero. Likewise, according to the second Gauss-Markov condition, equation

$$\sigma^2(\varepsilon_t)=\text{const}$$

is written in the econometric model, as it reflects that the population variance of the disturbance term should be constant for all observations.

In general, the initial form of regression model will look the following way:

$$\begin{gathered} Y_t = a_0 + a_1 \cdot X_{1t} + a_2 \cdot X_{2t} + \cdots + a_9 \cdot X_{9t} + \varepsilon_t \\ E(\varepsilon_t) = 0 \\ \sigma^2(\varepsilon_t) = const \end{gathered} \quad (30)$$

where:

Y_t the endogenous variable;

$X_{1t},\ldots, X_{9t}$ are the exogenous variables;

a_0 is the intercept coefficient;

$a_1 – a_9$ are the coefficients of the independent (exogenous) variables;

ε_t is the disturbance term.

The application of the ordinary least squares algorithm to the analysis of the consequences of imposing sanctions will be carried out on statistical data of macroeconomic variables.

Data that will be used further in this work was taken from Bloomberg database. This information covers the period of 10 years quarterly (from 2007 to 2016). There is only one endogenous factor GDP Y at current prices, measured in USD currency (in millions), as it is the most demonstrative indicator, which reflects market value of the sum of final goods and services produced in the economy. Exogenous factors are indicators, which in some extent influence GDP positively or negatively. Among them are:

- X_1– Interest rate (R) (%)
- X_2 – Inflation rate (%)
- X_3 – Unemployment rate (%)
- X_4 – Export to Russia (mln. USD)
- X_5 – Import from Russia (mln. USD)
- X_6 – Price of gas (USD/ cubic meter)
- X_7 – Government spending (G) (mln. USD)
- X_8 – Consumption (C) (mln. USD)
- X_9 – Trade balance (NX) (mln. USD)

Endogenous variable – GDP – an absolute measurement of economic activity of the country (the union of countries, in this case), calculated on a quarterly basis, includes all private and public consumption, government outlays, investments and difference between exports and imports (trade balance) that occur within a defined territory. Choosing exogenous variables, it is very important not to miss key factors, that influence GDP mostly, as there can be a risk of unreliable and not useful for econometric research model.

That is why, besides exogenous factors, that are directly connected with Russia (X_4, X_5, X_6), other relevant factors are included.

The interest rate, which is set by European Central Bank, can negatively influence GDP. By raising and lowering the interest rate, government can coax or put brakes on new investments (investment (I) as a component of GDP in expenditure approach increases GDP. Consequently, interest rate decreases it.) Moreover, higher interest rate is, then less disposable income citizens have (as they pay more interest for credits). Therefore, consumption decreases. Nowadays, interest rate became an important tool of monetary policy, as in long term rate shows the condition of the economy and the chance of inflation.

The inflation rate is a ratio of inflation, which is best described as growth in price in general, where inflation takes away purchasing power from currency. There are a few causes of inflation where aggregate demand increases faster than total supply, therefore multiplying the cost of goods and services within the economy. The imbalance of aggregate demand and supply is linked to the government's deficit, expansion of bank's interest rates and the increase in foreign demand. Inflation also enhances the price of goods and the price of work labour thus the cost of goods and selling price increases. So, inflation rate and GDP have an adverse outcome. Furthermore, as it can be seen in theory presented above, all these exogenous factors influence each other too, and unfortunately, there is a risk of multicollinearity. However, inflation rate or interest rate cannot be missed out on this stage, as they can be quite significant in econometric model. That is the primary reason why, it is necessary to keep a sharp eye on coefficients of exogenous factors, that they do not contradict with economic theory.

The unemployment rate, which means a share of jobless labour force, has opposite tendency in comparison with GDP, as GDP levels are driven by the principles of demand and supply, and increase in demand leads to an increase in GDP. When unemployment rate is high, a group of economically active people loses its purchasing capacity, therefore, GDP decreases.

In the theory of economics, in general, export and import have positive and negative coefficients accordingly, but in this case, factors are connected with trade only with one particular country. Sometimes these coefficients may have different signs because of inefficiency of trade (for example, low exporting prices) or other factors, that is tough to observe. As European Union imports natural gas from Russia, rising price of gas increases amount of money spent on imports, and therefore has a negative coefficient.

Last three exogenous factors were explained in Keynesian model in the previous chapter, and it is evident that government spending, consumption and net exports constitute GDP and have positive coefficients.

Overall, all statistical data, which is described above, is represented in the application at the end of the work. To sum up, these indicators have impact on GDP differently, but it is tough to predict what correlation analysis will show exactly in this particular case with the European Union and Russia, as there are too much circumstantial and not economic factors.

IV. Results

A. Statistical Outputs

To get the expected form of the econometric model with estimations, the coefficients of variables should be calculated. To do it, Analysis Tool pack in Excel ought to be used, or more precisely "Data Analysis". Then, by choosing "Regression Analysis" and corresponding columns of interest (Y and X_1, ... , X_9), we get the following results, presented in Table II

TABLE II: Regression Statistics

Statistics	Value
Multiple R	0,981
R Square	0,963
Adjusted R Square	0,951
Standard Error	18484,37
Observations	40

Adjusted R Square is a number that indicates how well statistical data fit a model – sometimes simply a line or curve. It is a statistic used in the context of statistical models whose main purpose is either the prediction of future outcomes or the testing of hypotheses, on the basis of other related information. It provides a measure of how well observed outcomes are replicated by the model, as the proportion of total variation of outcomes explained by the model.

The coefficient of determination for models with a constant takes values from 0 to 1. The closer the coefficient is to 1, the stronger the relationship. When estimating regression models it is interpreted as the model data. For acceptable models it is assumed that the coefficient of determination must be at least 50 % (in this case, the coefficient of multiple correlation exceeds 70 %). Adjusted R Square is approximately 0.951, which is a good result. This shows us the reasonably strong influence of all variables X_i on the GDP Y.

The Analysis of Variance, which represents a method in mathematical statistics that is aimed at finding dependencies in experimental data using investigating the significance of differences in the mean values, shows the following outcomes, given in Table III

TABLE III: VARIANCE ANALYSIS

	df	*SS*	*F*	*P-value*
Regression	9	263697985374.29	85.75	0.00
Residual	30	10250154364.14		
Total	39	273948139738.43		

An F-test is any statistical test in which the test statistic has an F-distribution under the null hypothesis. It is most often used when comparing statistical models that have been fitted to a data set, in order to identify the model that best fits the population from which the data were sampled. In other words, the F-test checks the overall significance of the regression model. Specifically, they test the null hypothesis that all of the regression coefficients are equal to zero. This tests the full model against a model with no variables and with the estimate of the dependent variable being the mean of the values of the dependent variable. The F value is the ratio of the mean regression sum of squares divided by the mean error sum of squares. Its value will range from zero to an arbitrarily large number.

The value of F-statistic is compared with a critical value of the Fisher criterion table of the Fisher distribution. If, as a result, it turns out that F is greater than the critical value of F, then at a given significance level we accept hypothesis on the significance of the model as a whole. If the result of the comparison is vice versa, at a given significance level the hypothesis on the significance of the model as a whole is rejected.

F_{crit} for this model is 2,21. F = 85.75 which means that $F>F_{crit}$ in our case. Thus, we can conclude that the quality of the model specification is high and the regression equation is statistically significant.

The next component of regression analysis is values of regression coefficients with 95% level of confidence, which are presented in Table IV.

Student's t-test deals with the problems associated with inference based on small samples, where the calculated mean and standard deviation may by chance deviate from the real mean and standard deviation. The t-statistic is computed by dividing the estimated value of the parameter by its standard deviation. This statistic is a measure of the likelihood that the actual value of the parameter is not zero. The larger the absolute value of t, the less likely that the actual value of the parameter could be zero.

TABLE IV: COEFFICIENTS OF REGRESSION MODEL

	Coefficients	Standard Error	t Statistics	P-value
Y-intercept	-3591422.49	851890.8	-4.22	0.00
X_1	30495.73	19466.7	1.56	0.13^*
X_2	-12916.26	6109.3	-2.11	0.04
X_3	45337.97	15009.6	3.02	0.01
X_4	-0.64	0.5	-1.24	0.22^*
X_5	-0.91	0.6	-1.53	0.14^*
X_6	6347.88	2488.2	2.55	0.02
X_7	-5.26	1.2	-4.28	0.00
X_8	3.93	0.4	9.79	0.00
X_9	0.35	0.5	0.68	0.49^*

The received value of t-statistics can be compared with table of t-statistics, which, depending on the size of the sample, show the percentage probability that it could occur by chance, when the true value of the coefficient was zero. So, to understand, whether the parameters are significant it is needed to find in the table or calculate the value of t critical and compare it with the received values of t.

The rules are similar to the case of F-test, which is if the absolute value of $|t|$ is more than t_{crit}, then we can conclude that this parameter is significant, and if the absolute value of $|t|$ is less than t_{crit}, then this parameter cannot be considered as a significant one, and can be changed to zero.

Finally, we receive t_{crit}=1.69, which is less than the absolute values of t-statistics values for majority of the model coefficients, but not for all. the coefficients for the variables X_1, X_4, X_5, X_9 turned out to be insignificant. The corresponding p-values are indicated by an asterisk in Table IV. For further analysis, we were forced to exclude these coefficients from the model.

In order to avoid multicollinearity it is needed to compare these coefficients to correlation coefficients and to exclude a variable, if coefficients have different signs. Using this method, Interest rate, Government spending and Inflation rate were dropped off. Consequently, we may continue to analyses the econometric model.

B. *Interpretation of the Model Coefficients*

Basing on the received new econometric model (without multicollinearity) and the coefficients of variables, it is possible to make conclusions about economic sense of relationship, that takes place between GDP of European Union and independent variables. To begin with, coefficient of X_3 (-23684,375) refers to the following: if unemployment rate in the European Union increases by 1%, its GDP decreases by 23684 million of US dollars. This high negative correlation can be explained that a fall of employment of economically active population leads to decline of production output, consumption, etc. Similarly, 1 million$ decrease of Export to Russia can be followed by increase in GDP of EU by approximately 823506$; and 1 million$ reduction of import from Russia can increase European GDP by roughly 3 million US dollars. Furthermore, if price of natural gas, that EU imports from Russia, rises by 1 US dollar per cubic meter, then European economy has a loss of 3520$ from each cubic meter of imported gas. In contrast, Consumption has positive relationship with GDP, and when people have more disposable income and they have opportunity to consume more, this situation results in increase of European GDP. The coefficient of X_8 (+1,57) means that positive change of 1 million $ of consumption increases GDP by 1,57 million$. Likewise, Trade balance, known as difference between export and import, has positive impact on GDP of European Union, as if it sells to foreign partners more than buys from them, European Union gets more profit from trade and GDP increases (regarding numbers, 1 million$ increase of net export changes positively GDP by 1,13 million$).

Interpretation of coefficients is crucial for making conclusions and predictions at the end of research work, as it gives clear understanding of the influence of factors in real market. After interpretation of all coefficients and identifying the economic sense of econometric model, it is recommended to check the reliability of model for future forecasts and its adequacy by several tests. All the tests that would be carried out forward are aimed at checking whether the constructed model can exist in real life and estimate influence of external factors.

The following step is to compare the dynamics of real Y_t (from the database) and estimated $\hat{Y}_t$, using the model. As you can see in Figure 5, real and estimated values are mapped quite close to each other. This means that the final model estimates the outcomes, which are close to reality and this model is trustful and reliable.

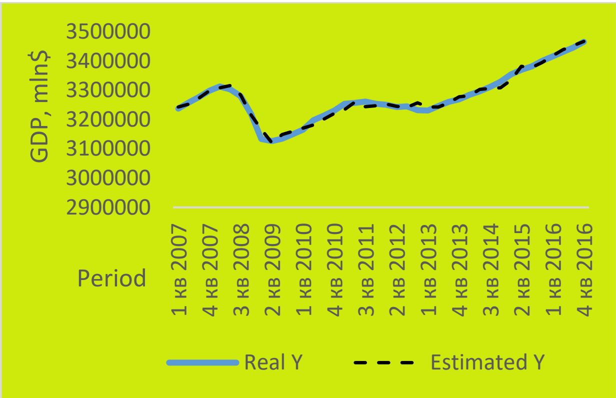

Fig. 7. Real and Estimated values of GDP of European Union.

C. Checking the Model Adequacy

To determine whether model is adequate or not, it is necessary to construct confidence interval, firstly. The range of trust is built in the following way:

1) To calculate Y_{teor}, using the regression equation with estimated coefficients (30)

2) To calculate Y^{-}_{teor} and Y^{+}_{teor}, using the formula

$$Y^{\pm}_{theor} = Y_{theor} \pm t_{crit} \cdot S$$

where S is standard error of the model.

The results, obtained in this work, are presented in the Table V.

TABLE V: THE CONFIDENCE INTERVAL

Y_{teor}	Y_{real}	Y^{-}_{teor}	Y^{+}_{teor}	Mistake δ
3466881,19	3465530,6	3446664,33	3487098,06	0,05%

In order to estimate the standard mistake of model approximation we should use general formula:

$$\delta = \frac{|\hat{Y}_{theor} - Y_{real}|}{Y_{real}} \cdot 100\%$$

This indicator is relatively small in every model, that means that mistake of approximation is relatively small, leading our model to better estimation of results and further forecasting. Model adequacy refers to the accuracy of the future forecasts. It is dramatically important for a research work, as the main aim for an analyst is to make conclusions and projections. Model is adequate, if the real value of dependent variable Y_{real} belongs to the confidence interval.

Thus, the real value of Y lies within the confidence interval (3446664,33;3487098,1).

Error of forecasting equals 0,05%. It can be concluded, that the probability of the mistaken forecast is very low.

To conclude, the updated econometric model is reliable, adequate and can be used for analysis and forecasting.

D. Economic Analysis of the Model Results

The central notion underlying the model designed for this research was to verify, how exactly the EU would proceed after having severed or at least severely restricted its trade turnover with Russia. As it is showcased in the model, the EU is not particularly dependent on its ties with Russia in order to continue flourishing. Throughout this research, we have obtained a model, which best highlights the connection formed between Russia and the EU via studying the links between the aggregate GDP of the EU and the values for the export to Russia and import from Russia, as well as the price for gas, as the EU is the primary consumer of the Russian gas resources and the Russian economy relies heavily on the commodity prices, such as oil and gas.

The tests, which we performed after having adjusted the model to the case of reality and its circumstances, clearly demonstrate the European economy does not depend on the Russian imports, therefore the Russian economy is losing more than its gaining in terms economic benefits. Moreover, the received econometric model shows that EU is not very interested in exports to Russia, as sometimes it may bring negative outcomes.

The point to be taken here is the fact, that if the Netherlands and Germany are amongst Russian biggest trading partners, this is rarely the case with the EU, which can always resort to the US, China and Japan, as well as other developing markets. Therefore, Russia is forcing itself to shut down its trade with one of its, if not the biggest, trading partners willing, while having no economic premise to do that whatsoever.

V. CONCLUSIONS

The conclusion to be drawn here is the fact that, first, the model, which we obtained throughout our research is reliable and can be used to forecast the developments in the actual EU-Russia relations. The overall conclusion is the EU does not depend on Russia simply because the share of the Russian exports and imports is too insignificant as well as the fact that the current price of gas does not enable Russia to be an economic powerhouse. The case will remain so until Russia revives its economy or the commodity prices go up again. However, this is very improbable due to the fact the commodity market has got a larger diversity. Therefore, there is feasible way for Russia to become the sole supplier of the EU, thus rendering it considerably more important and influential in the eyes of the Brussels.

However, the current state of affairs in the EU-Russia relations may prove beneficial in the long run, as Russia will be forced to develop its own technologies and unique concepts instead of just exporting its commodities to the EU in exchange for investments and manufactured goods. At the same time, this may not be the case as Russia will further on lag the developed world and the deprivation caused by the sanction and a partial embargo may hinder the scientific and economic progress in Russia.

Regarding the consequences of sanctions and contra-sanctions, European economy as a whole was not significantly damaged, especially by embargo, and figures of Export to Russia in the received model prove this. However, Exports to Russia have been partly affected in two ways. Firstly, by the EU ban on the sales of certain goods, such as 'dual-use' technology intended for the exploration of oil and gas, as well as the product embargo as a way to put up a fight to reciprocate for the EU sanctions, for example on meat. The European Union supply firms sustain some losses. Secondly, the rouble's depreciation, exacerbated by capital flight from Russia, has weakened Russian purchasing power. Since sanctions and the economic crisis in Russia, some categories of export do not undergo sanctions also face deteriorating prospects, due to spill-over effects and the worsening economic situation.

Taking into account all ideas presented above, Russia and European Union are capable of becoming trusted trade partners, only if any political decisions will be made in a rational way by calculations, similar to this research work. Otherwise, it is better for Russia to search for new markets to cooperate with, as in current conditions only Russia have dramatic losses in several economic indicators.

The model, which has been obtained throughout the research is certain to be reliable. However, it only relies on three key factors, which are crucial for understanding the EU-Russia relations. To expand the model, some additional factors should be added as well as a comparison between the EU-US, EU-China and China-Russia [15] economic relations. Moreover, this model cannot be used for the full analysis of the economy of European Union, as it does not include structural key factors, such as Consumption, Government spending, Investment etc.

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