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Econometric model of dependence between the oil prices, and the global external debt level and oil production

Abstract. The article comprises theoretical discussion of the influence of the revenues obtained from the exploitation of oil reserves on the external debt level in the countries of the world. Econometric methods are applied to analyse statistical data for 2003-2016 and quantitative characteristics of this influence. It was concluded that rise in oil prices results in growth of the national external debt. We found that 1% growth in oil prices increases the volume of foreign debt to the unit of GDP of the world for 3.17%.
Keywords: Oil Prices; Natural Resources; External Debt; World GDP; Global GDP; Econometric Modelling
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Економетрична модель залежності світового рівня зовнішнього боргу та видобутку нафти від цін на нафту
Анотація. У роботі висвітлено теоретичні аспекти залежності зовнішнього боргу країн світу від прибутків, отриманих від використання запасів нафти. Для вивчення такого впливу застосовано економетричні методи аналізу статистичних даних. В результаті дослідження виявлено, що зростання цін на нафту веде до зростання рівня зовнішнього боргу, а саме, до зростання відношення зовнішнього боргу до одиниці виробленого ВВП.
Ключові слова: ціни на нафту; природні ресурси; зовнішній борг; світовий ВВП; економетричне моделювання.

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Эконометрическая модель зависимости мирового уровня внешнего долга и добычи нефти от цен на нефть
Аннотация. В работе рассмотрены теоретические аспекты зависимости уровня внешней задолженности стран мира от доходов, получаемых от использования нефти. Данная зависимость раскрыта в результате применения эконометрических методов анализа статистических данных. В результате исследования доказано, что рост цен на нефть приводит к росту уровня внешнего долга, а именно, к росту отношения внешнего долга к единице произведенного ВВП.
Ключевые слова: цены на нефть; природные ресурсы; внешний долг; мировой ВВП; эконометрическое моделирование.

1. Introduction

Amid truly global outreach of the latest financial crisis and its protracted impact on both developed and developing economies, it is obvious that shifts in oil production volume and changes of oil prices are among other factors that has crucial effect on the current state of the world economy.

Over the years, oil prices became an important financial indicator which helps to value an economic system of the world. The increasing attractiveness of future oil deals and the available derivatives in these contracts produced the capital inflow into the oil markets. Thus, the raw material market has become the element of the financial market.

It is well known that the lack of finances is one of the main obstacles to the economic growth of emerging markets. There is always lack of foreign currency on such markets, primarily because of lower level of export incomes.

The lack of foreign currency makes its rate higher than that of local currency. Rising oil prices creates a surplus of funds in countries which produce and sell oil. Later these funds are lent to developing countries which need finance. Thus, we can observe that the rising oil prices cause the growth of the total amount of government debt in the world. Also, we have to note that oil prices may have a speculative character as it is defined by financial markets. Globalization of contemporary world economic system has connected many sectors which may affect the oil prices, including political one. Oil prices are also closely linked to currency rates. This link can be especially noticed in the rate of the US dollar, as far as dollar is a nominal currency which rate can be used to calculate real economic indicators (GDP, inflation rate) and refinancing rates. Oil prices affect currency rates of different countries in different way. Currency rates in oil producing countries suffer of lower oil prices, because their local currency began to weaken due to decrease in export incomes. If we look at the information provided by the Ministry of Finance of Azerbaijan for 2011-2017, we see that the volume of Azerbaijan's external debt rose from the

USD 3,857.3 million to USD 6,913.2. However, if we compare external debt figures in Azerbaijani manat (AZN), we can see bigger difference in its value - it grew from AZN 4,753.2 million in 2014 to AZN 12,241.3 million in January 2017. This period was the time of sharp decline in the oil prices. From 2011 to 2016 US dollar rate strengthened, and that affected economic indicators in Azerbaijan as well as in any oil selling country. That is why, in order to protect their local currencies, the biggest oil exporter countries (OPEC) try to control oil prices via reducing the volume of production (Worldbank, 2016).

In our research paper, we used econometric model to show the interconnection between oil prices and combined external debt of the world. The analysis is made on data covering 14 years. Methodology of our research is based on the descriptive statistics and econometric modelling techniques. Also, the statistical significance of given dependence in the model has been verified, and its usefulness for forecasts has been proved.

2. The research problem and literature review

There are numerous scholarly researches on issues of natural resources development, as well as oil-rich countries pattern of economic behaviour, which analyse relation between exploitation of these resources and soundness of development. For instance, a widely used «Dutch disease» and «Resource curse» terms also came as a result of such studies. Exploitation of oil resources is being done presently by transnational corporations, and revenues are distributed among all the participants who influence the global economic processes. Most of existing works analyse economic development issues of resource rich countries. At the same time, significant share of produced energy commodities is exported to different countries and has sound effect on their economies. As a result, exploitation of resources in oil-rich countries has influence far beyond their borders, to most elements of the global financial and economic processes.

As mentioned above, natural resources influence country's economic development. One of the most analysed problems in oil-gas rich countries is «Dutch disease». In literature, the negative influence of natural resources on economic development is reviewed under the «Resource curse» clause [1]. In many resource-rich countries economy's ability to recover is ailing, thus, prices plunge or scarce resources directly impact the economic growth. Studies of this phenomenon determined several scenarios to unfold [3]:

- «Dutch disease»;
- rent oriented behaviour and institutional degradation;
- political instability and declining physical and human capital.

Recently, many scholars re-evaluated the phenomenon of «resource curse» in Russia, with its abundance of natural resources [6-8]. A number of studies specifically address effects of «Dutch disease» for Azerbaijan [24-25; 32], as well as the impact of oil revenues on the national currency value, import-export operations, price level of non-tradables.

According to many researchers, most influential factor to the human capital deficit is «resource curse» problem. The impact by this factor is estimated to be around 11-25% [3, p.181-193; 4, p.1011-1039]. In Suslova & Volchkova (2007) and Vasilyeva (2012) the influence of natural resources on human capital savings level in Russia was analysed.

Many economists see human capital as the main driver of economic growth. The knowledge economy and other investments into human capital produce increased output in the economy. In contrast, investment in the physical capital shows a decreasing output. As an example, an investment has been allocated for the purchase of equipment or for construction purposes. Of course, over time structures and equipment are exposed to physical and moral erosion and, as a result, reduced productivity. Contrary, the effectiveness of the investments in education and science only increases over time. Thus, vehicle sold once is going through the constant decline in price, while teachers' knowledge is not devaluing and constantly produces new knowledge as an outcome of the transferring to the students. Higher level of education in the country multiplies effects by scientific and technological progress.

According to the studies, human capital also determines the quality of the management in the economy. Besides, there is a high probability of introduction of the democratic governance and respect to the private property in the countries with high level of human capital. In many instances, developed human capital also contributes to the reduction of the level of corruption [5, p. 44-49].

A number of studies have shown that spendings of resource-rich countries on education are smaller than in non-resource dependant countries with the same level of income [10]. In resource-rich countries, stimulation level to invest in human capital is low because of low demand for highly classified labour. «Dutch disease» and «rent-seeking behaviour» are the reasons for these. High level of rent income in sectors of mining, and non-tradable goods and services helps to increase production level, whilst processing and agricultural sectors that produce merchandise decrease it [11]. Usually, skilled labour is not required in the mining sector growth [12]. If incomes of institutions which can re-distribute incomes are higher than in production areas or entrepreneurial activity, then people prefer to work for government agencies [13-14]. One of the reasons is that the government sector is less exposed to the international competition. Also, government sector prefer to consume goods and services by the national entities. The low level of competition further reduces demand for the skilled labour. National business is aware that the government is going to protect the local production, either by raising customs tariffs or by direct subsidies, even if it is non-competitive [2].

The high level of inequality is immanent in the resource-oriented countries, and it impacts negatively the development of the human capital [12; 15]. Even if there is a request for quality education on the labour market, social inequality in society is hampering investments in human capital.

Exploitation and export of natural resources produce the abundance of foreign currency, and lead to the increase in the national currency's value. The high value of the national currency and low value of foreign currency stimulates import. Inflow of cheaper goods into the country stimulates the changes in the structure of capital. In other words, cheaper fiscal and financial capital reduces the demand for labour and human capital.

Many scholars investigated the hypothesis that rich natural resources in the country have the negative influence on the accumulation of human capital, but there is still no solid result on this issue [3; 4; 9; 15-18; 20-22]. Moreover, there are examples of the natural resource-rich developing countries where human capital development is at high pace [16, p. 1765-1779].

Statistical analysis of the impact of the natural resources on the accumulation of human capital provides conflicting results. Gylfason (2001) [10], Papyrakis & Gerlagh (2004) [3], Suslova & Volchkova (2007) [9], Papyrakis & Gerlagh (2007) [4] discovered negative correlations, while Davis (1995) [4], Alexeev & Conrad (2009a, 2009 b) [18-19] discovered positive correlations, and Stijns (2006) [17], Papyrakis, Gerlagh & Gylfason T. [15], Blanco & Grier R. [20] ended up with mixed correlations between variables. Suslova & Volchkova (2007) [9] concluded that developing and resource-rich countries have a high level of human capital accumulation. However, most of the analysis estimated the negative correlation between rich natural resources and accumulation of human capital. Studies of Azerbaijani economy shows the shortage of skilled labour to fully involve in the physical capital [23].

3. Theory and methodology aspects

In the study by Hasanli (2014) [25] the pattern of reproduction by K. Marks was modified to meet modern requirements and to justify the process of formation of «extra revenue» from the exploitation of natural resources. In the process of exploitation of natural resources demand for marginal product in non-natural resources sector is growing, followed by the growth of their import.

The Keynesian theory gives three motives for the money demand: transaction motive, precautionary motive, and speculative motive. In the second, precautionary motive, the money demand is set according to future and unexpected operations [26, p. 91]. The first and the second motives are classical in terms of economic history, they are widely depicted by classical economists. The scale of money demand under these motives proportionally depends on income. The level of the money demand under the third motive depends on income and interest rates. The surplus income generated from the exploitation of natural resources stimulates the money demand on the third motive. In other words, increase of the level of securities demand further produces growth in national debt. Income surplus from the exploitation of natural resources leads to money surplus, and this process spirals up to the «financial bubble» in the financial markets, including security market. «Financial bubble» is seen by many experts as a key factor behind the global financial crisis of 2007-2008. Numerous research support the statement that easily earned money in real estate and securities markets can lead to financial crises [27, p. 204].

Thus, we can say that there is a positive correlation between oil prices and level of international indebtedness which is exposed in our research by the following formula:

Tab. 1: **Oil prices, GDP, external debt and external debt to GDP ratio**

Years	Crude oil brent USD/bbrl (annual averages), USD for barrel	Total world GDP (Gross Domestic Product, current prices), billion USD	External debt globally, billion USD	External debt to GDP ratio (globally), or external debt to GDP unit
T	OP	GDP_W	ED_W	ED_W/GDP_W
2003	28.85	38,981.88	2,000	0.05
2004	38.3	43,884.47	2,000	0.05
2005	50.76	47,532.87	12,700	0.27
2006	65.39	51,457.55	36,890	0.72
2007	72.7	58,052.03	44,610	0.77
2008	109.53	63,650.74	51,780	0.81
2009	61.86	60,279.11	60,960	1.01
2010	79.64	65,899.81	56,900	0.86
2011	110.44	73,083.78	60,280	0.82
2012	112	74,437.72	69,080	0.93
2013	108.9	76,458.18	72,850	0.95
2014	98.9	78,519.56	72,970	0.93
2015	52.4	74,196.85	74,740	1.01
2016	44	75,278.05	75,890	1.01

Source: Compiled by the authors based on IMF and WB data [33-35]

$$ED\_W = f(OP) + u,$$

where ED_W indicates a total value of an external government debt in the world, OP - the oil prices (in our case, those for Brent oil), and u is a random error in this dependence.

Specifications for the model to depict this correlation have been evaluated via econometric tools.

4. Data collection and empirical results

Data under analysis is presented in Table 1.

Figure 1 shows oil price dynamics based on Table 1, and Figure 2 depicts dynamics of the level of external debt to GDP per unit globally.

Comparative analysis of dynamics in Figure 1 and Figure 2 shows that there is direct dependency of the level of foreign indebtedness to the unit of the world GDP from the oil prices. Data in Table 1 show dramatic changes in prices in 2009 and 2015. To determine how those changes contributed to the final results, we considered it appropriate to include two dummy variables to the model [28].

Modelling and testing. To create a stationary feature of analysing data as a dependent variable, we have chosen the level of foreign indebtedness to the unit of the world GDP (ED_W/GDP_W).

The following logarithmic linear regression equation is applied to show the relation between the level of foreign indebtedness to the unit of the world GDP (ED_W/GDP_W) and the oil prices (OP).

$$LOG(ED\_W/GDP\_W) = C(1) + C(2)*LOG(OP) + C(3)*DUMMY2015 + C(4)*DUMMY2009, \quad (1)$$

where $C(1)$ and $C(2)$ are parameters of an equation, e is a random deviation. $C(2)$ characterizes the influence of the stable factors which have not been taken into account, $C(1)$ is a coefficient of elasticity. In other words, it shows the change of dependent variable in percents, according to 1% change of independent variables (external debt to GDP ratio and oil prices).

The model (1) was represented by the regression equation (1) and tested by the Least squares method to the proper data from Table 1, with the use of Applied Program Packet Eviews7 (Econometric Views) [29].

The main statistical characteristics of the model are presented in Table 2.

According to Table 2, econometric model can be written as following:

$$\underset{(s.s)}{LOG(ED\_W/GDP\_W)} = \underset{(1.551097)}{-14.4693440041} + \underset{(0.358795)}{3.17288294906}*LOG(OP) + \underset{(0.332261)}{2.04763058581}*DUMMY2015 + \underset{(0.411961)}{1.27848865248}*DUMMY2009 + e \quad (2)$$

R-squared = 0.897992; Adjusted R-squared = 0.867389; Durbin-Watson stat = 1.970314.

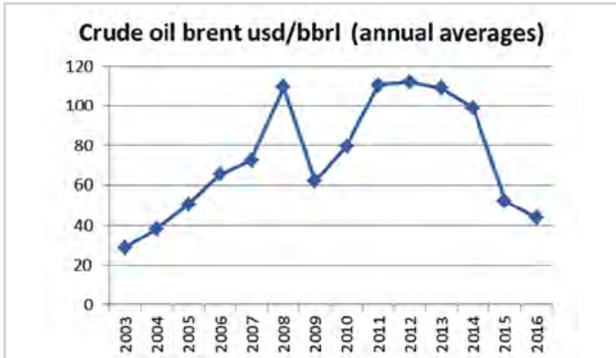

Fig. 1: **Oil prices dynamics**
Source: Compiled by the authors based on IMF and WB data [33-35]

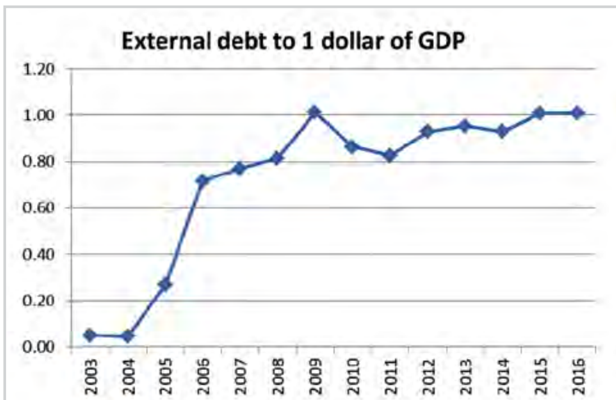

Fig. 2: **Dynamics of external borrowing level to GDP per unit**
Source: Compiled by the authors based on IMF and WB data [33-35]

Statistical characteristics and the t-test of coefficients in the regression equation given in Table 2 show that the values found for coefficients are significant in more than 99.9%. Note that we were testing the significance of influence of different indicators to the dependent variable with t-statistics. The value of t-statistics is high and p-value (t-Statistics) is close to zero if standard error of parameters significantly smaller than the value of coefficient. P-value (t-Statistics) characterizes the non-influence probability of independent variable to the dependent variable in the model (H0 is supported as p-value is closing to 0). The cost of determination coefficient (R-squared = 0.897992) shows that within the period of time under analyses shift of indicator ED_W/GDP_W is 89.8%. It depends on changes of the costs of explanatory indicators OP.

Tab. 2: **Statistical characteristics of the econometric model**

Dependent Variable: LOG(ED_W/GDP_W)
Method: Least Squares

Sample (adjusted): 2003-2016
Included observations: 14 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.46934	1.551097	-9.328458	0.0000
LOG(OP)	3.172883	0.358795	8.843171	0.0000
DUMMY2015	2.047631	0.332261	6.162724	0.0001
DAMMY2009	1.278489	0.411961	3.103419	0.0112

R-squared	0.897992	Mean dependent var	-0.621293
Adjusted R-squared	0.867389	S.D. dependent var	1.073872
S.E. of regression	0.391058	Akaike info criterion	1.195036
Sum squared resid	1.529265	Schwarz criterion	1.377623
Log likelihood	-4.365250	Hannan-Quinn criter.	1.178134
F-statistic	29.34381	Durbin-Watson stat	1.970314
Prob(F-statistic)	0.000029		

Source: Elaborated by the authors

Other 10.2% shift occurs as a result of the influence of non-stable factors not taken into account. Slight difference in the values of the coefficients of determination and adjusted determination (adjusted R-squared) tells that the sample regression line fits the data and it is not random.

As the Durbin-Watson statistics is equal to 1.97, it means that there is no first compiling autocorrelation between the indicators, which is desirable. Note that the value of Durbin-Watson statistics changes in the range of (0; 4): there is a positive autocorrelation if the value of coefficient is closer to zero, and negative autocorrelation if the value nears 4. If DW statistics is closer to 2, that indicates that there is no autocorrelation, which can be seen in our case [29, p. 421-423; 30, p. 621-632].

If all disturbances have the same variance, it is one of the Gauss-Markov conditions which indicates the adequacy of the model [31, p. 41]. The case of stable disturbances represents homoscedasticity, while non-stable case shows heteroscedasticity. There are some testing methods for these cases in applied economics program Eviews. One of them is Breusch-Pagan-Godfrey test of heteroscedasticity. Its result is provided in Table 3. As we analysed them, we rejected heteroscedasticity of disturbances hypothesis and accepted homoscedasticity hypothesis, because probability value of Fisher's F-statistics is higher than 0.05 significance level.

The results for Dickey-Fuller test applied to determine the stationarity of disturbances show that disturbances in our model can be defined as non-stationary. Thus, the absolute value of t-statistics (4.03) is greater than the critical value at 90% (see Table 4). It means that disturbances of the model (2) can be taken as stationary only at significance level higher than 90%.

One of the important steps in disturbances diagnostics is normality testing (see Figure 3). Histogram shows that the mean of disturbances in the model is significantly closer to zero. Standard deviation is equal to 0.34. It indicates that disturbances spread around the average value with the small interval. The dimension of Kurtosis is equal to 2.55, which shows the shape of disturbances. This indicates the existence of the deviation from the normal distribution. Note that the ideal value of Kurtosis is equal to 3. In general, Jarque-Bera test for normality has shown that the distribution within the model can be considered normal distribution [30; p. 646-648].

Approximate level of actual values of the model is presented in Figure 4. It shows that the values from the model (2) are significantly close to the actual numbers.

5. Conclusion

Today, oil is the only commodity to be under constant attention and review not only by business community but by the wide

Tab. 3: **Heteroscedasticity Test of Breusch-Pagan-Godfrey**

F-statistic	0.809760	Prob. F(3,10)	0.5169
Obs*R-squared	2.736274	Prob. Chi-Square(3)	0.4341
Scaled explained SS	1.082698	Prob. Chi-Square(3)	0.7813

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 2003 2016
Included observations: 14

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.761871	0.572678	1.330366	0.2129
LOG(OP)	-0.146409	0.132470	-1.105222	0.2949
DUMMY2015	-0.143102	0.122673	-1.166530	0.2705
DAMMY2009	-0.152677	0.152099	-1.003799	0.3391

R-squared	0.195448	Mean dependent var	0.109233
Adjusted R-squared	-0.045917	S.D. dependent var	0.141177
S.E. of regression	0.144382	Akaike info criterion	-0.797754
Sum squared resid	0.208461	Schwarz criterion	-0.615166
Log likelihood	9.584278	Hannan-Quinn criter.	-0.814656
F-statistic	0.809760	Durbin-Watson stat	2.888280
Prob(F-statistic)	0.516910		

Source: Elaborated by the authors

Tab. 4: **Dickey-Fuller Test**

Null Hypothesis: RESID02 has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=2)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.036538	0.0008
Test critical values:	1% level	-2.771926	
	5% level	-1.974028	
	10% level	-1.602922	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 12

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID02)
Method: Least Squares
Date: 07/03/17 Time: 12:36
Sample (adjusted): 2005-2016
Included observations: 12 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID02(-1)	-1.327260	0.328812	-4.036538	0.0024
D(RESID02(-1))	0.386507	0.237029	1.630630	0.1340

R-squared	0.646352	Mean dependent var	0.076150
Adjusted R-squared	0.610987	S.D. dependent var	0.455624
S.E. of regression	0.284177	Akaike info criterion	0.472571
Sum squared resid	0.807564	Schwarz criterion	0.553389
Log likelihood	-0.835428	Hannan-Quinn criter.	0.442650
Durbin-Watson stat	1.688248		

Source: Elaborated by the authors

public. Testing the model (1) which was presented in a form of logarithmic linear regression equation to show the relation between the level of foreign indebtedness to the unit of the world GDP and the oil prices may be considered as adequate that means there is a positive correlation between oil prices and the level of foreign indebtedness to the unit of the world GDP. Testing the model (1) using the Least squares method allowed us to formulate an econometric model (2) for further application. The values found for coefficients of the model (2) are significant in more than 99.9%. Within the results of Breusch-Pagan-Godfrey

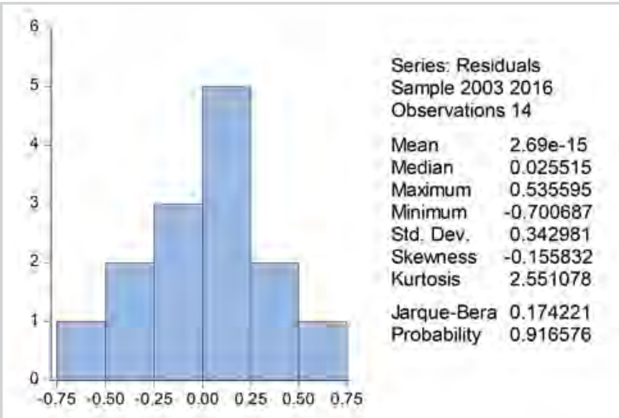

Fig. 3: **Histogram of disturbances in the model (2)**
Source: Elaborated by the authors

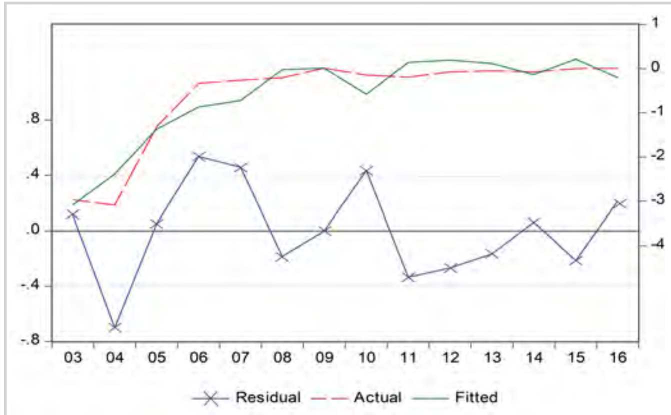

Fig. 4: **Graphical description of fitted, actual and residual values from the model (2)**
Source: Elaborated by the authors

test, we rejected heteroscedasticity of disturbances hypothesis and accepted homoscedasticity, because probability value of Fisher's F-statistics is higher than 0.05 significance level. Dickey-Fuller test has shown that disturbances in our model can be defined as non-stationary. Jarque-Bera test for normality has shown that the distribution within the model can be considered as normal distribution. The value of elasticity coefficient C(2) of the model (2) is equal to 3.17. According to this, we can say that 1% growth in oil prices increases the volume of foreign debts to the unit of GDP of the world for 3.17%.

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