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# Study of functional dependence of Ukraine budget deficit on Tax and other revenues

Ukraine budget deficit state has a set of influence factors, the main of which after formalization should be taken into account within the study of functional dependence of Ukraine budget deficit on tax and other revenues.

We emphasize that the reasons for the emergence of the country's budget deficit are the decrease of output and the reduction of budget revenues (recession), declined efficiency of individual branches, delayed structural changes implementing in the economy or its technological upgrading; military expenditures; efficiency of the tax system, the presence of shadow economy, the excessive government spending on individual budget items. We underline that the budget deficit is the phenomenon that inherent national economy in general. At the same time, for the population the budget deficit has an indirect importance, because the population is involved in returning borrowed funds for covering the deficit by paying taxes.

In modern economic literature different impact models of Ukraine key macroeconomic indicators on the budget balance state are presented. Basically there are econometric models as a single-factor and multifactor linear regression models that describe for example the budget deficit impact on GDP, or the taxes impact on GDP or tax revenue impact on spending budget, etc.

Modeling the correlations between Ukraine budget deficit and macroeconomic dynamics indicators in the economic literature is presented by various models, such as:

- -The model of the taxes amount impact on the Ukraine budget deficit in the form of two-factor regression of expenditures dependence model as % of GDP and tax revenues [1];
- -The model of budget deficit control and its components operation, that exploring its increment rates and detecting inverse correlations between relative and absolute budget deficit indicator [2];

-The modeling post-crisis economic processes with GDP forecasting, as well as modeling the impact on GDP the budget revenues and retail trade turnover [3];
-The model of external direct and guaranteed debt, depending on the budget deficit state [4];
-The model of state regulation of the fiscal system based on the Solow growth model [5];
-The model of the budget debt capacity [6].

In works [7, 8] the importance of optimal compromise between the striving of the state to get rid of the budget deficit and the negative increasing taxes effect on production is analyzed taking into account the future macroeconomics development and it is emphasized that if the economy is growing, the taxes can rise, and vice versa, if the economy falls down, significant tax rates will deepen the recession.

We emphasize that the methodology of balancing the budget is not justified. Budget in which revenues are equal to expenses stimulates production growth. However it is investigated that the production growth with a balanced budget will be minimal.

Thus, a balanced budget is minimal incentive for production and should be a means to stimulate production, rather than its reduction tool. Table 1 shows singled out by us the main macroeconomic impact indicators on the budget deficit state.

For modeling the impact of the Ukraine main macroeconomic indicators on the budget deficit state we hypothesized the presence of functional correlation between budget deficit of Ukraine and the main macroeconomic indicators such as GDP, trade balance, balance of payment, government debt and taxes, that can be represented as a linear multiple regression model. This linear multiple regression model will enable within the ascertainment of acceptable level of determinism to analyze the influence degree of parameters on the budget deficit magnitude.

We emphasize that the formulation and formalization of statistical data output occur at a priori building stage of the linear multiple regression model. Statistical data of introduced independent variables of the main macroeconomic indicators is proposed to consider for the period 1998-2013, that is corresponding macroeconomic indicators are considered exactly at the same time and spatial intervals of their operation.

*Table 1*

**The main macroeconomic impact indicators on the state budget deficit**

| **macroeconomic indicators** | **indicators** |
|---|---|
| Economic Growth (GDP) | Growth rate and their reduction through particular industries<br>Growth rates of GDP components structure<br>Index of employment<br>indicators of economy innovation development |
| balance of payments (Trade balance) | Deficit of the accounts<br>Adequacy of foreign exchange reserves<br>Terms of trade and capital flows<br>Import covered by export |
| Public debt | External and internal debts and their correlation<br>The correlation between balance of payments' current account and external debt |
| Tax revenues | state budget revenues, tax revenues and their effectiveness<br>Revenues of business in targeted state programs<br>Customs duties and other regulatory tools used by the state |
| Inflation | Volatility of inflation |
| Interest rates and exchange rates | Volatility of interest rates and exchange rates<br>The level of real interest rates of the domestic market<br>The stability of the exchange rate<br>Ensuring support of the exchange rate |
| lending volumes growth rate and value of assets | The growth of lending volume<br>The rising cost of assets |
| Market risks | The risk of foreign exchange rate changes<br>The risk of interest rates changes<br>The risk of commodity prices changes<br>The risk of changes in value of financial instruments |
| Main characteristics of financial market | the market value of financial instruments<br>credit rating<br>Yield of government bonds |
| Other factors | Government loans and investments<br>The use by the state the resources of banking system<br>The total amount of indebtedness in the economy |

We consider the analysis of tax revenues to the budget.

If we analyze the direct and indirect taxes in some EU countries, the overall level of direct taxes is estimated about 70%. The level of indirect taxes introduces the positive changes in the tax systems of European countries. We suppose that these changes primarily concern the reduction of taxes share on consumption.

For the study of the functional dependence of the Ukraine budget deficit on tax and other revenues we analyze the dynamics of Ukraine tax statistics for the period 1998 -2013 in millions UAH. This data due to natural normalization become dimensionless in the range from 0 to 1 after transferring it though the formula [15]:

$$P_{r(\text{dimensionless})} = \frac{P_r^* - \min_i P_i^*}{\max_i P_i^* - \min_i P_i^*}, \qquad (1)$$

where $i$ - index data change, $P_i^*$ - statistical data series of macroeconomic indicator, $\min_i P_i^*$ - the minimum value in a number of statistical data series, $\max_i P_i^*$ - the maximum value in a number of statistical data series, $P_r^*$ - fixed number of statistical data series, $P_r$ - transferred dimensionless value that corresponds to a fixed value of statistical data series.

We obtain the dimensionless dynamics taxes value which is reproduced in Figure 1.

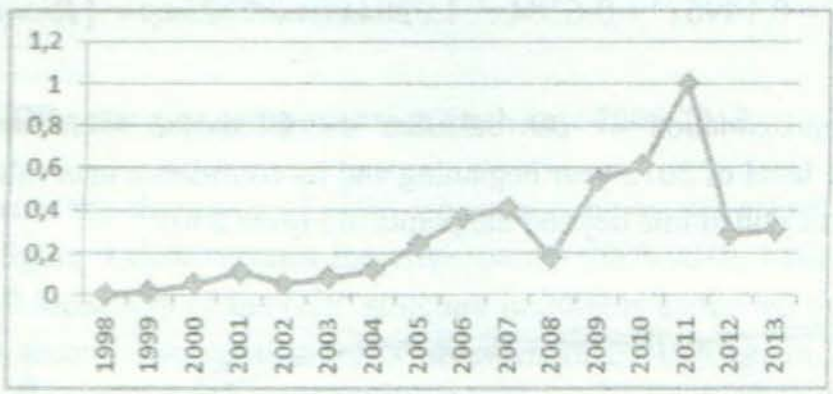



**Figure 1. The dynamics of dimensionless taxes value of the state budget item for the period 1998 -2013**

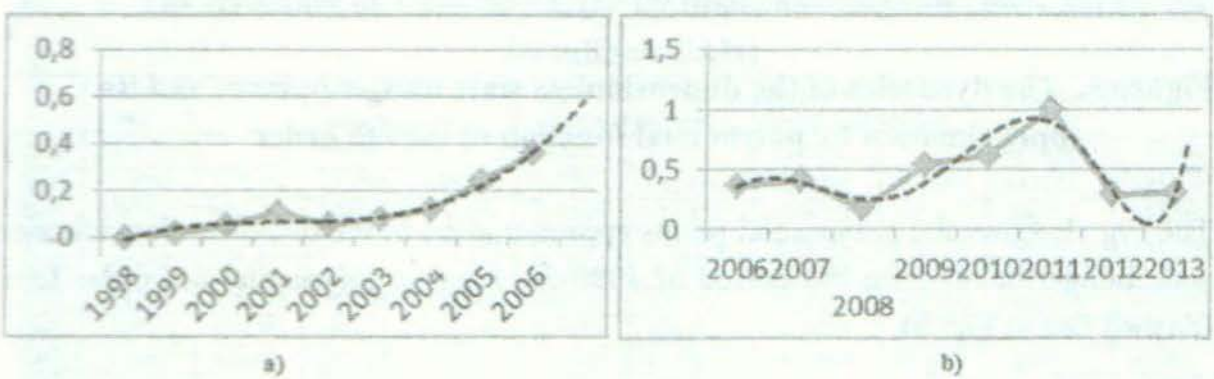



**Figure 2. The taxes dynamics approximation by analytical functions**

The curve configuration of dimensionless series of Ukraine tax dynamics at Figure 1 shows that due to different character of points behavior it is reasonable to consider two periods 1998-2006 and 2006-2013. The point location trend for the period 1998-2006 is of the approximate nature to the branches of the cubic parabola, and for the period 2006-2013 it has a very different trend (Figure 2 a), b)).

At the Fig. 2 a) the polynomial points approximation of the dimensionless taxes from the state budget item for the period 1998-2006 using the polynomial 3rd order form is presented:

$$y = 0.0024x^3 - 0.0292x^2 + 0.1206x - 0,1047, \quad \left(R^2 = 0,9696\right) \tag{2}$$

At the Fig. 2 b) the polynomial points approximation of the dimensionless taxes from the state budget item for the period 2006-2013 using the polynomial 5th order form is presented:

$$y = 0.0013x^5 - 0,1496x^4 + 0.6384x^3 - 1.0204x^2 + 0.7725x, \quad \left(R^2 = 0,8442\right) \tag{3}$$

Using this approximation we can calculate the forecasted value which tends to increase at the level of 2012 year beginning and its confidence intervals for the 2014 (continuation of dotted line beyond the points in Figure 2 b)).


**Figure 3. The dynamics of the dimensionless state budget balance and its approximation by polynomial function of the 6th order**

The Fig. 3 shows the polynomial points approximation of the dimensionless Ukraine state budget balance for the period of 1998-2013 using polynomial 6th order form (dashed line at Fig. 3):

$$y = -0.00001x^6 + 0.0007x^5 - 0,142x^4 - 0.1352x^3 - 0.6398x^2 + 1.3688x, \quad \left(R^2 = 0,829\right) \tag{4}$$

Using this approximation we can calculate confidence intervals of predictive value (continuation of the dotted line beyond the point). Figure 3 shows that the forecast tends to decrease significantly.

We analyze the gross domestic product (GDP) of Ukraine. Table 3 shows the structure of Ukraine's GDP by final consumption (GDP calculated at current market prices is called nominal GDP).

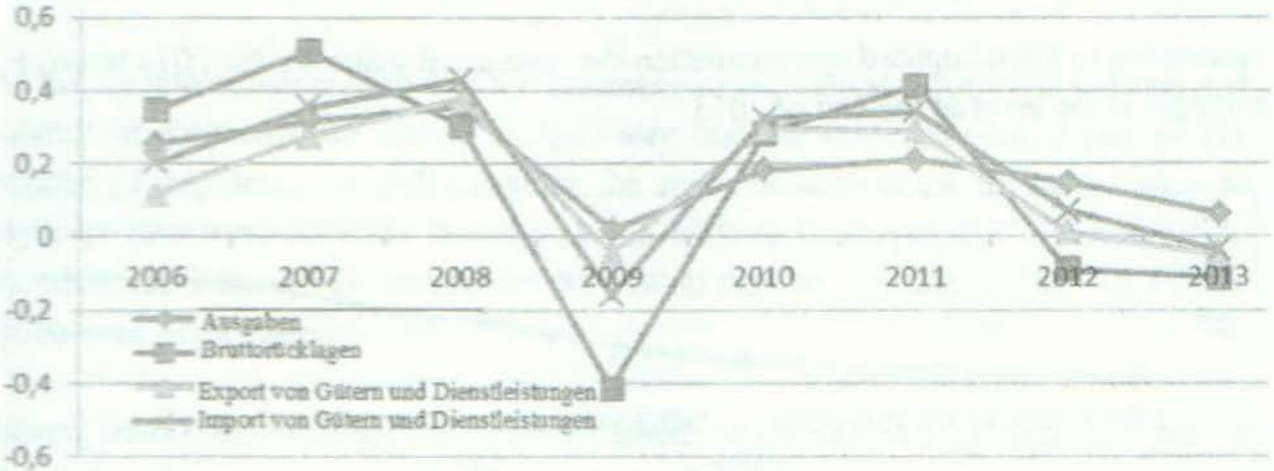



**Figure 4. GDP structure components growth rate 2006-2013**

Fig. 4 presents the dynamics of GDP structure components growth rate by 2006-2013. The figure 4 demonstrates the crisis period 2008-2010, besides that a sharp decline of all indicators of the GDP structure in 2009 is explained by the post-crisis inertia. The second sinusoidal wave is observed in 2010-2012. In 2013 there is a gradual decrease of all components of the structure in comparison to 2012.

*Table 3*

**The structure of Ukraine's GDP by final consumption 2005- 2013 (in million UAH)**

| | consumer costs | | gross accumulation | | Export of goods and services | | Import of goods and services | | Nominal GDP per year | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 337879 | | 99876 | | 227252 | | -223555 | | 441452 | +27.9% |
| 2006 | 424060 | +25.5% | 134740 | +34.9% | 253707 | +11.6% | -269200 | +20.4% | 544153 | +23.3% |
| 2007 | 558581 | +31.7% | 203318 | +50.9% | 323205 | +27.4% | -364373 | +35.4% | 720731 | +32.5% |
| 2008 | 758902 | +35.9% | 264883 | +30.3% | 444859 | +37.6% | -520588 | +42.9% | 948056 | +31.5% |
| 2009 | 772826 | +1.8% | 155815 | -41.2% | 423564 | -4.8% | -438860 | -15.7% | 913345 | -3.7% |
| 2010 | 914230 | +18.3% | 199918 | +28.3% | 549365 | +29.7% | -580944 | +32.4% | 1082569 | +18.5% |
| 2011 | 1105201 | +20.9% | 282474 | +41.3% | 707953 | +28.9% | -779028 | +34.1% | 1316600 | +21.6% |
| 2012 | 1269601 | +14.9% | 257335 | -8.9% | 717347 | +1.3% | -835394 | +7.2% | 1408889 | +7.0% |
| 2013 | 1350220 | +6.3% | 228474 | -11.2% | 681899 | -4.9% | -805662 | -3.6% | 1454931 | +3.3% |

The dynamics of Ukraine's GDP statistics which were listed by the formula (1) for the period 1998 -2013 is shown at Figure 5. The decline in GDP in 2009 can be explained by inertia after the crisis. The polynomial points approximation of dimensionless GDP by using the 4th order form (dotted line in Figure 5) is submitted:

$$y = -0,00005x^4 + 0.0013x^3 - 0.0061x^2 + 0.0209x, \quad \left(R^2 = 0,9929\right) \tag{5}$$

According to the computed approximation the forecasted value for the 2014 trends to increase at the level of the end of 2013.

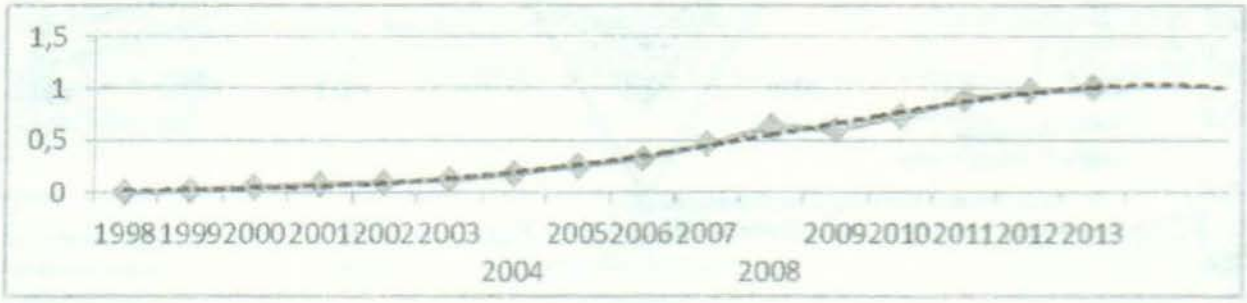



**Figure 5. The dynamics of dimensionless GDP and its approximation by the function**

We analyze the balance of payments and trade balance of Ukraine. We should notice that the balance of payments includes: the trade balance; payments and receipts for services, noncommercial payments, income from foreign investments, long-term and short-term movement of capital and foreign exchange reserves.

Thus, the part of the balance of payments, which reflects both exports and imports, is called state trade balance (i.e. the balance of payments is wider than trade balance).

We emphasize that the state of the balance of payments is determined by the current international monetary system and, in turn, affect its operation. At the same time, the vast amount of the payments made by the external payment obligations refers to trade balance as a ratio of exports and imports value of the country with its trading partners. If exports exceeds imports, the trade balance is considered to be positive (or active), and if imports exceeds exports – it will be negative (or passive). In addition, in the first chapter of the balance of payments services trade is reflected (tourism, communication services, maintenance of military bases abroad). The balance of

current operations shows the overall results for the trade balance and the services accounting.

It is not possible to use in linear multiple regression model of these two interrelated macroeconomic indicators, because the variables must be independent of each other, but their impact on the Ukraine budget balance should be highly considered. It is known that the factors which are included in the multiple regression should not be correlated with each other and especially not to be in the functional dependence.

So, taking into consideration that the macroeconomic indicators of trade balance and balance of payments are linked in such way that the trade balance is part of the balance of payment, we will consider the trade balance share in the balance of payment (the ratio of trade balance to the balance of payments). Therefore, we introduce the independent variable of the models such as the ratio of trade balance to the balance of payments.

Among basic numerical approximation methods of tabular data towards the ratio of the trade balance to the balance of payments of Ukraine we use the approximation by quadratic function (Figure 6). Fig. 6 represents polynomial points approximation of the trade balance to the balance of payments ratio by using square trinomial form:

$$y = -0.0021x^2 - 0.062x + 1,5944, \quad \left(R^2 = 0,7841\right) \quad (6)$$

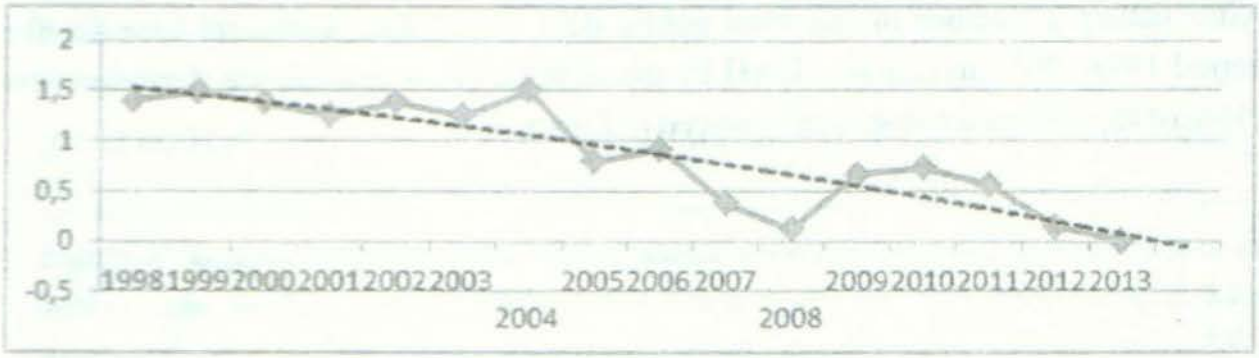



**Figure 6 The dynamics of the trade balance to the balance of payments ratio and its approximation by quadratic function**

This approximation by analytical function was chosen among several approximations and the criterion for selection was the best standard deviation error. Using this approximation the predictive value (dashed line at Figure 6) for 2014 tends to monotonous decrease. Besides that the analytic function smoothes fluctuations points

in three periods: 2001- 2005, 2005- 2009, 2009- 2012.

We consider the total public debt, which includes both internal and external public debt. In the work [9], the dependence of the linear multiple regression of the external public debt is presented as the objective function and the independent variables: GDP, balance of payments, exchange rate.

We notice that the selected macroeconomic indicators such as GDP, current account of the balance of payments, the rate of the national currency against foreign currencies do not fully describe the changes in the structure and dynamics of the external public debt. This may be due to the selected type of model, which becomes a prerequisite for further change of the data analysis methods. Regarding the controversial conclusion towards the connection of the balance of payment current account and external debt, it must be said that the current account deficit is acceptable if it does not endanger the solvency of the country and does not lead to excessive accumulation of the external liabilities. Foreign debt is also very sensitive to sudden changes of the exchange rate, which leads to a significant increase in the amount of debt.

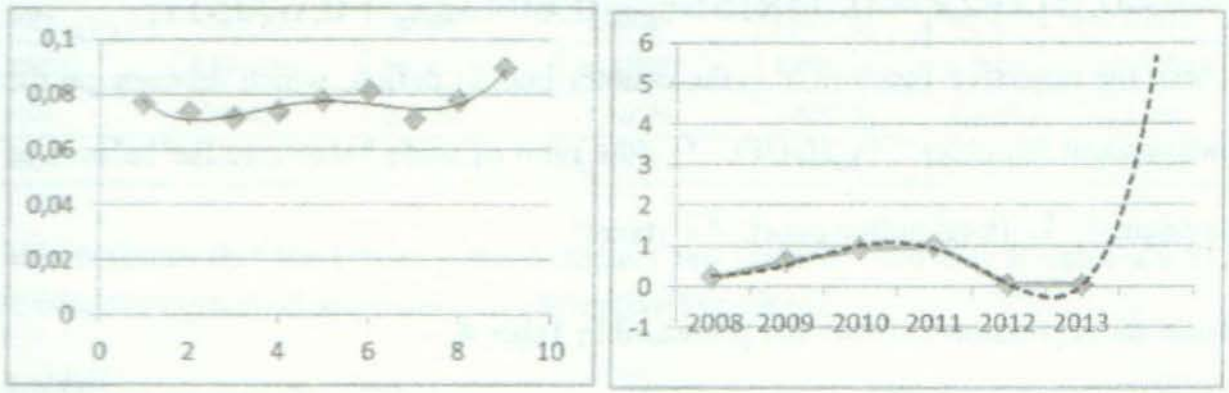
We assume that other indicators which have not been included in the analysis: the energy sources dependence of import, the necessity of gold and exchange reserves increasing and so on affect the rapid growth of foreign debt.

After listing a number of the total public debt of Ukraine statistical data for the period 1998 -2013 in millions UAH by the formula (1) we obtain the dimensionless value of this dynamics that is reproduced at Figure 7.


**Figure 7. The dynamics of dimensionless total public debt for the period 1998-2013**

Fig. 7 shows that the dynamic series can be divided into two periods: 1998-2008 and 2008- 2013, besides that within the first period the trend point location has even character that is closer to the linear nature, so approximate dimensionless point of public debt since 2008.

In the second period 2008-2013 the configuration curve of total state debt of Ukraine is changing dramatically and is sinusoidal in nature. Therefore, we approximate these two periods separately, and then we will combine them.




a) b)

**Figure 8. The dynamics of dimensionless total public debt for the period 1998-2008 and its approximation**

In Fig. 8 a) the polynomial points approximation of dimensionless total public debt is represented for the period 1998- 2008 using the 4th order form of polynomial function:

$$y = 0,0001x^4 - 0.0022x^3 + 0.0144x^2 - 0.0362x + 0.1011, \quad \left(R^2 = 0,8149\right) \quad (7)$$

Figure 8 b) represents the polynomial points approximation of dimensionless total public debt for the period 2008- 2013 using the 5th order form of polynomial function:

$$y = 0.0013x^5 - 0,1496x^4 + 0.6384x^3 - 1.0204x^2 + 0.7725x, \quad \left(R^2 = 0,09774\right) \quad (8)$$

Using this approximation the predictive value (dashed line at Figure 8) for 2014 year tends to increase significantly.

So for the next modeling stage the superposition of two approximations of dimensionless total public debt for two periods are considered and presented at Figure 8.

For further modeling we will use time series aligned data of the Ukraine key macroeconomic indicators by approximations (2) - (8).

Linear multiple regression equation is constructed as:

$$y = -0,21782x_1 + 0,748155x_2 - 0,60435x_3 + 0,67251x_4. \quad (9)$$

where the objective function Y – the country budget deficit, which depends on the independent variables: $x_1$ (GDP), $x_2$ (the ratio of trade balance to the balance of payments), $x_3$ (total public debt), $x_4$ (taxes).

Thus, the regression statistics are presented in Table 4.

*Table 4*

**Regression statistics of the model**

| **Regression statistics** | |
|---|---|
| Multiple R | 0,999267 |
| R-squared | 0,998535 |
| Normalized R-squared | 0,907226 |
| Standard error | 0,032999 |
| Observation | 15 |

Dispersion modeling analysis are presented in Table. 5. The significance of the multiple regression equation is estimated by using Fisher's F- criterion where MS is the factor sum of squares per one degree of freedom; the critical value of the Fisher's F- criterion is shown in Table 5.

*Table 5*

**Dispersion analysis of the model**

| | *df* | *SS* | *MS* | *F* | *F value* |
|---|---|---|---|---|---|
| regression | 4 | 8,164705 | 2,041176 | 1874,43 | 2,51263E-14 |
| remainder | 11 | 0,011979 | 0,001089 | | |
| total | 15 | 8,176683 | | | |

The regression statistics of the multiple linear regression model of the functional dependence of country budget deficit on major macroeconomic indicators is presented in the Table 6.

*Table 6*

**Regression statistics of the model**

| | coefficients | Standard error | t- statistics | P-value | lower 95% | higher 95% |
|---|---|---|---|---|---|---|
| Y- intersection | 0 | 3,57E-16 | -6,4E+13 | 9,89E-15 | -0,02298 | -0,02298 |
| 0,0001 | -0,21782 | 0,05887 | -3,70005 | 0,003501 | -0,34739 | -0,08825 |
| 1,406567 | 0,748155 | 0,010714 | 69,82969 | 6,45E-16 | 0,724574 | 0,771737 |
| 0,0001 | -0,60435 | 0,11261 | -5,36679 | 0,000228 | -0,85221 | -0,3565 |
| 0,0001 | 0,67251 | 0,127364 | 5,28023 | 0,00026 | 0,392184 | 0,952836 |

Table 6 shows that the Fisher's and Student's test statistics and also P-value are in the range of perceived acceptance of alternative hypothesis.

Taking into account that all independent variables were considered in dimensionless form, we can concluded that the greatest impact on the balance of budget deficit the second variable reveals - the ratio of trade balance to the balance of payments (coefficient of 0.745185> 0), then by the degree of impact on the budget deficit taxes reveal (the fourth variable by a factor of 0.672551> 0). As for GDP (coefficient - 0.21782 <0) and public debt (coefficient of -0.21782 <0), they do not significantly affect the state budget deficit.

With built models we can calculate predicted values of key macroeconomic indicators that we have chosen as the most influential on the balance value of the state budget and find the confidence limits of individual predictive values and confidence limits for the expected value (point and interval forecasts).

Thus, the model of multiple linear regression is developed, what became possible after the approximation and smoothing time series of main macroeconomic indicators of Ukraine. The regression statistics was calculated and the dispersion analysis was conducted and also the remainders according to the confidence probability, which is given by: 0,97 was presented. It is shown that the greatest impact on budget deficit the second variable reveals - the ratio of trade balance to the balance of payments, then by the degree of impact on the state budget deficit taxes

reveal. With regard to GDP and public debt, they do not significantly affect the state budget deficit.

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