

**Macroeconomics**

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**MODELING RELATIONSHIP BETWEEN PUBLIC  
AND PUBLICLY GUARANTEED EXTERNAL  
DEBT OF UKRAINE AND BUDGET DEFICIT,  
SPENDING AND SAVINGS**

**Abstract**

The dynamics of external public and publicly guaranteed external debt of Ukraine, the budget deficit and spending and savings in Ukraine in UAN and US-Dollar since 1996 to the present date were analyzed and their trends were built. An emphasize was laid on the following periods: 1996–2006 – a period of sustained economic development (pre-crisis), characterized by slow growth of debt; 2007–2011 – a period of rapid growth in debt (crisis); 2012–2014 – a period of sustained growth in debt (post-crisis); since 2015 until now – a period of a new economic crisis. The predictive values of the debt were calculated for 2017–2021. The method of harmonic scales was applied, based on the principle of aging information, and according to a point projected values of public and publicly guaranteed debt. Their intervals were calculated. The econometric models de-

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pendence of the total external public debt of the budget deficit in Ukraine and vice versa was calculated. It was established that the increasing of the budget deficit by 1% of the GDP leads to an increasing total external debt to 41.856 billion UAH or 3.8762 billion USD. It also leads to an increasing debt by 1 billion USD and to an increasing deficit in the budget to 0.2507% of the GDP. The econometric models depending on costs and savings from debt in UAH and US-Dollar were constructed. It was found that the growth of the total external debt of the state by 1 billion UAH was accompanied by rising costs and savings by 4.637 UAH. The distributed lag model depending the costs and savings from debt in UAH was constructed and equivalent with a delay in one year, according to the increasing total external debt by 1 billion UAH is accompanied by increasing costs and savings next year by 4.2848 billion UAH. The distributed lag model depending the costs and savings on debt in US-Dollar without displacement was constructed. It is founded that the increasing in total external public debt by 1 billion USD increases the amount of costs and savings on 3.6858 billion USD. Models that examine these figures in UAH and US-Dollars show the good consistency of increasing coefficients. The model with instrumental variables was calculated, which shows that the costs and savings are incremental in nature. It was established that the increasing in spending and savings in the current year by 1 billion UAH leads to increasing costs and savings of 1.06771 billion UAH next year. It is shown that the growth of debt by 1 billion UAH leads to increasing costs and savings to 0.0243 billion UAH.

### **Key words:**

Gross external debt, public and publicly guaranteed external debt of Ukraine, costs and savings, budget deficit, trend, time lag, distributed lag model, economic modeling, the method of the instrumental variable, the method of the prediction with harmonic scales.

**JEL:** C3, C32.

**Actuality.** The instability and uncertainty of the economic situation in Ukraine, deficit of the budget system, limited of the internal funding sources and their expensive for the ensuring the financing of the Ukrainian economy stipulate the urgent need to attract resources in foreign markets. Government borrowing as instrument of economic policy performs not only function of balancing public finances and also exercises indirect influence on a number of economic processes and phenomena. At present the current state of the global financial system can be described as a crisis of excessive debt manifesting EU debt crisis. External debt is part of the economic system, performing both direct and indirect effects on the state budget, monetary and currency system, inflation, internal and external savings, foreign investment and so on. Thus, external debt affects the Ukrainian economy in general, and the possibility of its effective using in the majority are determined the general level of economic development and affect virtually all elements of the economic system.

**Methodological base of research.** A significant number of scientific issues of foreign economists are devoted to research of the impact of public debt on the economy of the country. Classics of the political economy (Adam Smith, David Ricardo, J. S. Mill) have saw public debt as unambiguously negative phenomenon which is a significant burden for the state and causes problems with his service in the future. However, J. M. Keynes does not reduce the public debt to the rank of indisputable negative and considers it as one of the effects of stabilization policy, creating a model of deficit financing (Keynes, 1999, p. 97), which is largely dominant in the economic practice of developed countries (Rozhko, 2013, p. 51–53).

Theoretical and practical aspects of effective management of sovereign debt deals in the works of local scientists H. Kuchera, V. Kalytchuka, T. Vahnenko, I. Raka, I. Lyutoho, A. Sihayova, Yu. Subotovych, O. Cheberyako and V. Fedosova at al. For the transitional economy of Ukraine as noted in the H. Kuchera and V. Kalytchuka (Kucher, 2007, p. 51) the using of a lower indicators of the debt burden is required since the present transformation involves not only a radical reform of structural and institutional foundations of the economy and society, but also the choice of a new model of macroeconomic balance.

As stated in the T.Vahnenko external loans with long terms refunds become a significant source of funding for investment in Ukraine's economy. At the same time we should not overestimate the role of foreign loans in the performance of basic tasks of economic development. It is necessary to mobilize domestic sources for investment in the national economy and to create general economic conditions for their effectiveness (Vakhnenko, 2007, p. 17–24). K. S. Yekymova (Ekimov, 2011, p. 283] believes that public debt can be only

when all the expenses made for maintenance and debt payments contribute to increase state revenue in future periods. It is desirable that the involved funds will be aimed at investment. It should be noted that Ukrainian scientists – T. Bohdan, V. Dudchenko, O. Korniychuk, V. Kozyuk, S. Yuriy have made a significant contribution to the study of the role and value of public debt in the economy. The generalization of foreign experience, theory and methodology of public debt have presented in their scientific work. As noted T. V. Chernychko emergence of the debt may be due to objective and subjective reasons. The objective include: worsening of the global economic situation that adversely affect to domestic production; debt obligations incurred in connection with the change of social system and transfer of succession and related to previous loans; the formation of new states in connection with the collapse of world empires that have accumulated debts; the using of new production technologies in the advanced industrial countries and more. The following reason: incorrect exchange rate policy of the National Bank of Ukraine; incorrectly designed and approved the budget law of Ukraine; misuse of budget funds; insufficient preparation and non-transparent tenders of public procurement; ineffective economic activity can be attributed to subjective reasons (Chernychko, 2014, p. 311).

**The purpose of the article.** The identifying of the trends in debt security of Ukraine and the prospects for financial stability and economic development in the context of the relationship of external public debt, deficit and cash income on the basis of econometric modeling is the purpose of this article.

All issues of the above authors are descriptive and they have not forecasts of total external debt of the state. Also the causal connections between the debt and principal macroeconomic indicators have not founded. Therefore this work is devoted to the analysis of public and publicly guaranteed external debt of Ukraine, the budget deficit, spending and savings, installation of their dynamics trends for forecasting of these indicators and determines the causal relationship between the total external debt of Ukraine, the budget deficit and spending and savings based on econometric modeling.

**Research results.** Formation of external public debt of Ukraine began relatively recently, when Ukraine gained independence. At the time of the collapse of the USSR Ukraine had no foreign debt obligations to the USSR debt, as Russia has assumed responsibility for all the debts of the Soviet state (66 billion USD at the end of 1991). Since 1992 Ukraine has seen a gradual intensification of foreign borrowing on international financial markets.

According to the World Bank methodology (depending on the debtor) foreign debt consists of two parts: direct public and publicly guaranteed debt and private non-guaranteed long-term debt.

A particular obstacle is that common results of the statistical evaluation of the dynamics of Ukraine's public debt do not have a single statistical or analytical research base through-whole period of Ukraine's independence and now. By

1999, the debt is calculated according to the methodology of the World Bank, and from 1999 – according to the IMF methodology. Analyzing statistics (Table 1), we note that for the period 1996-2016 years dynamics of the growth of public and publicly guaranteed external debt is unstable because it affected the socio-economic processes in Ukraine. So that it can be divided into the following periods: 1996–2006 – a period of sustained economic development (pre-crisis); 2007–2011 – a period of rapid growth in debt (crisis); 2012–2014 – the period of slowing growth in debt (post-crisis); from 2015 to the present – a period of new economic crisis. The first period can be characterized as relatively stable, in which the total amount of foreign debt in dollars increased slightly from 8.9 billion USD and reached its maximum value 12.5 billion USD in 1999. In the other years of the period the fluctuations of this indicator are observed. According to the dynamics of the trend, described by a linear model, the average annual growth of debt in the pre-crisis period was 0.16 billion USD. The second period covers the onset of the global economic crisis that began in late 2007. At this time the debt has increased in 2.45 times from 15.27 to 37.47452 billion USD and correspondingly in UAH equivalent debt has increased in 3.87 times respectively from 77.1135 to 298.582 billion UAH. It should be noted that since 2011, there is a slowdown of growth of debt, in 2013 – debt had negative growth. The third period is characterized by the beginning of the formation of a stable economic situation in the country. In 2013, debt decreased by 2.9% compared to the year 2012, and in 2014 the debt increased by only 0.35% compared to 2012. The fourth period (the period of new economic crisis), which began in 2015, is marked the worst and most acute for the national economy economic indicators.

Since 2015 the level of total public debt rises sharply. In 2015, debt has increased by 12% compared to the year 2014, and in 2016 – increased by 1.83% over the 2015 year. The level of external public and publicly guaranteed debt in 2015 was amounted 43.4454 billion USD (949.547 billion UAH), in 2016 – 44.2401 billion USD (1127.968 billion UAH). Thus, external public and publicly guaranteed debt had increased by almost 12% in 2015 compared to 2014, in 2014 compared to 2013 it increased only by 3.35%. In the fourth period (new economic crisis) increasing in debt due to objective reasons: dramatic changes in government policy have taken place as a result of the changing of power after the tragic events of winter 2014, that affected the financial and economic sphere. In addition, the annexation of the Crimea and East Ukraine Russian occupation was during this period that leading to significant cost budget of Ukraine for its defense. This year, 2015 and 2016 are marked the worst and most acute for the national economy economic indicators.

A technical default could be the result of a sharp rise in the budget deficit and increasing debt in the summer of 2015. In this case, the IMF made financial assistant for the maintenance of the Ukrainian economy, because the economy collapse in at least one country can cause of the negative changes in internationally developments.

Table 1

**The public and publicly guaranteed external debt, costs and savings of Ukraine's population for 1996–2016 years**

Years	Deficit of the budget, % of GDP (Electronic resource)	Public and publicly guaranteed external debt		Costs and savings	
		billion USD (Electronic resources)	billion UAH (Electronic resources)	billion USD (Electronic resources)	billion UAH (Electronic resources)
1996		8,9	16,8121	20,6252	38,961
1997		9,7	18,3233	25,3748	47,933
1998		11,6	39,7532	15,57514	53,376
1999		12,5	65,20375	11,41	59,518
2000		10,4	56,57808	15,39962	83,777
2001		10,2	54,79542	19,14242	102,835
2002		10,2	54,33132	34,74505	185,073
2003		10,7	57,05989	40,4433	215,672
2004		12,1	64,36232	51,55681	274,241
2005		11,7	59,95899	74,42465	381,404
2006		11,2	56,56	94,91267	479,309
2007	1,4	15,27	77,1135	123,4236	623,289
2008	1,32	18,53804	97,64354	160,5485	845,641
2009	3,89	26,51868	206,6124	114,7815	894,286
2010	5,94	34,75961	275,8383	138,7639	1101,175
2011	1,79	37,47452	298,582	158,988	1266,753
2012	3,79	38,6588	308,9263	182,436	1457,864
2013	4,45	37,536	300,0252	193,7612	1548,733
2014	4,98	38,7922	461,2315	127,5688	1516,768
2015	2,28	43,4454	949,547	79,7937	1743,979
2016		44,2401	1127,968		

In summary, the trends of total public external debt in dollar and UAH equivalent were constructed. Note that in our work the debt trends for certain periods were constructed and made forecasts. Point forecasts for 2014, 2015 and 2016 were accounted to 44.813; 48.551; 52.289 and 34.536; 29.467; 22.198 billion USD according to a quadratic model. So the real values of debt in these years, which are respectively 38.7922; 43.4454 44.2401 billion USD, are inside these intervals, indicating the high reliability of econometric modeling (Lya-shenko, Kovalchuk, 2016; Ivashchuk, 2008, p. 704).

The statistics for 1996–2016 years are used to constructing of their trends. The trend of debt in dollar terms for this period is described by the following models:

$$y = 0,1246t^2 - 0,7696t + 10,462 \quad (R^2 = 0,924)$$

end

$$y_t = -0,0094t^3 + 0,4352t^2 - 3,5674t + 16,178 \quad (R^2 = 0,9393).$$

Note that from 1996 to 1999, the amount of debt in dollars increased slightly, from 2000 to 2003 practically unchanged, while in 2006–2007 it observed their fluctuations in both upward and downward in the respective years [8 9].

Since 2007, we note a significant increase in public debt. Trend debt in dollars during the years 2007–2016 is described by a linear model

$$y_t = 3,0664t + 16,658, \quad (R^2 = 0,8548),$$

where  $t$  – the time factor. Fisher criterion is used to investigate the adequacy of the model. It is calculated  $F_{emp}=47.1$ . Since  $F_{emp}$  is greater than  $F_{kr}=5.52$  for reliability level  $p = 0.95$ , the model is adequacy. The Durbin-Watson method is used to investigate the residual autocorrelation. It is calculated  $DW_{emp} = 1.3375$ . It is impossible to make definite conclusions about the presence of autocorrelation for reliability level  $p = 0.95$  and  $n = 10$  ( $d_L = 0,88$ ;  $d_U = 1,32$ ). The autocorrelation is absent to lower reliability. The Glejser-test is used to check of heteroscedasticity in which the linear regression of the absolute values of residues should look as  $|u_t| = -0,2752t + 4,6302$ . For numbers degrees of freedom  $k = 8$  and level of reliability  $p = 0.95$  ( $t_{kp}=1,86$ ),  $t_\beta = 1,3263$ . That indicates the insignificance angular coefficient and thus absence of the heteroscedasticity.

The quadratic model

$$y_t = -0,4004t^2 + 7,4708t + 7,8493, \quad (R^2 = 0,9481)$$

with high coefficient of determination could also be used to forecast in not-deterioration of the economic situation as it reflects the tendency to a possible decline in total external public debt.

The dynamics of the debt in UAH for the years 1996–2016 (Fig. 3) can also be described by quadratic dependence

$$y_t = 4,5857t^2 - 63,666t + 198,6 \quad (R^2 = 0,8562),$$

that also points its annual growth.

Figure 1

**Dynamics of external guaranteed debt, billion USD**

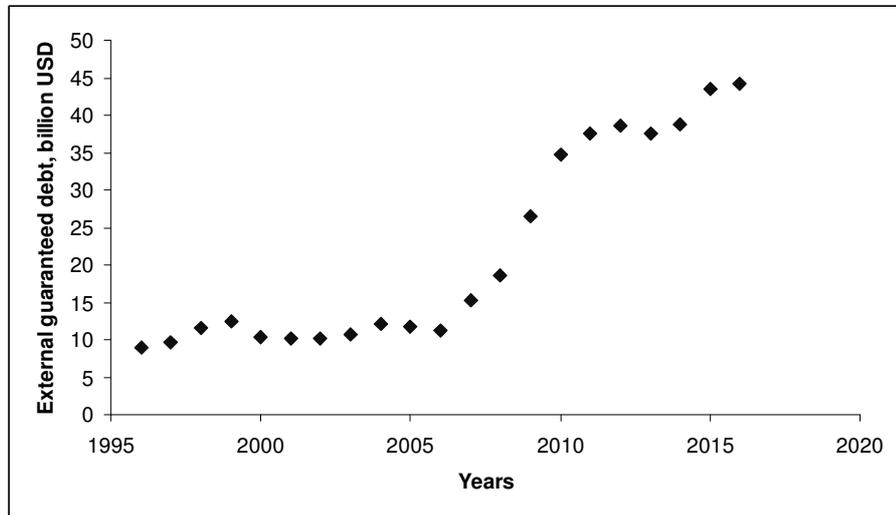


Figure 2

**Dynamics of external publicly guaranteed debt, billion UAH**

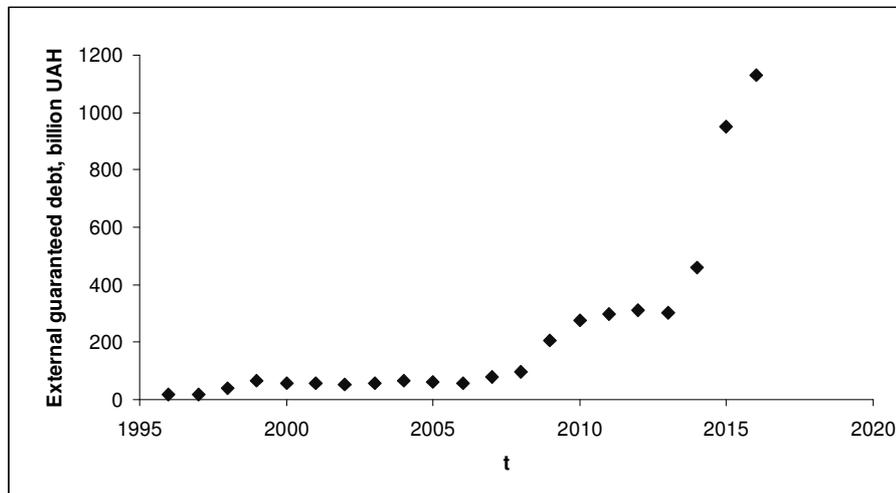
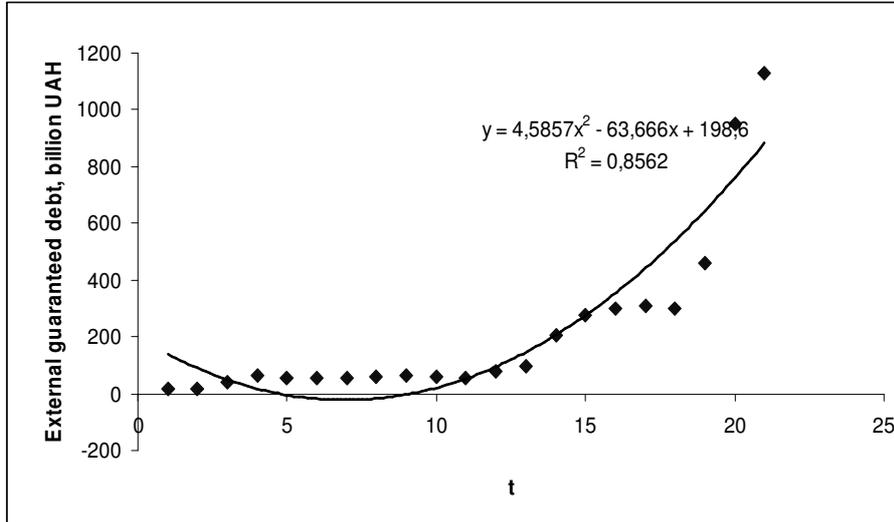


Figure 3

Trend of guaranteed external debt, billion UAH



Some difference between trends debt in UAH and dollars may be associated with the dynamics of the dollar [14] (Fig. 4). From 1996 to 1999 the course of the dollar relative to the UAH slightly increased since 1.889 to 5.2163 USH, from 1999 to 2008 remained almost at the same level, in 2009 abruptly rise to 7.7912 UAH and remained constant until 2012(Fig. 4). From 2012 to 2016 the dollar increased by almost linear dependence  $y_t = 4,0074t + 0,3831$  ( $R^2 = 0,9011$ ). At the end of 2016 the average dollar exchange rate is 25.4965 UAH.

Estimated value of the debt in dollars while maintaining the tendency of the economy in 2017, 2018, 2019, 2020 and 2021 years, according to the model  $y_t = 3,0664t + 16,658$  can be respectively 50.39; 53.45; 56.52; 59.59; 62.65 billion USD and debt in UAH in the same period according to the model  $y_t = 4,5857t^2 - 63,666t + 198,6$  may be 1017.43; 1160.12; 1311.98; 1473.01; 1643.22 billion UAH. Also for the level of significance  $p = 0,95$  confidence intervals of expectations values of external guaranteed debt in USD are calculated and presented in Table 2.

Figure 4

## The dynamics of the dollar over the period 1996–2016 years

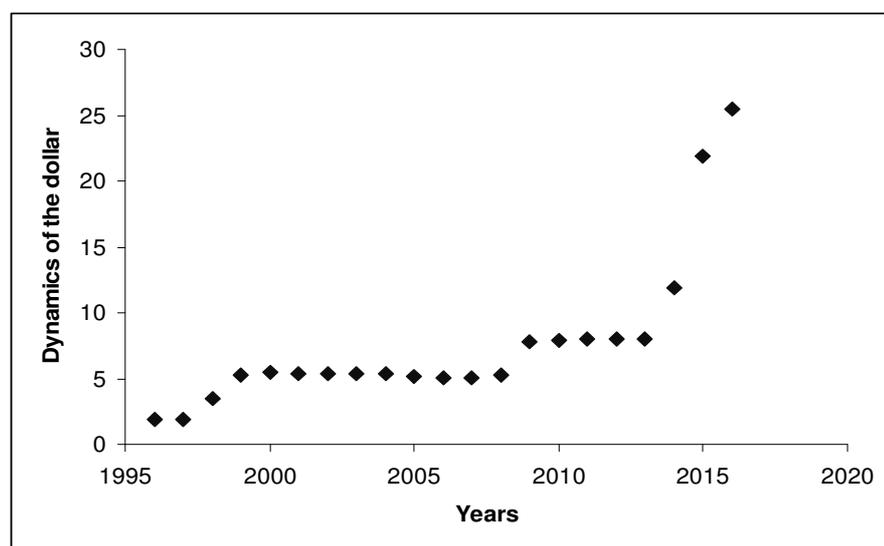


Table 2

## Forecasting values of the external guaranteed debt, billion USD

Years	External publicly guaranteed debt, billion USD		
	forecasting value	lower boundary	upper boundary
2017	50,39	41,03	59,75
2018	53,45	44,1	62,81
2019	56,52	47,16	65,88
2020	59,59	50,23	68,94
2021	62,65	53,3	72,01

To forecast we used the method of harmonic scales, taking into account the principle of aging information (Novak, 2004, p. 209–214). According to this principle, new information reveals the estimated value of more influence than the old. Forecasting procedure in this case is divided into two separate phases:

- 1) time series smoothing of the predicted variable using additive trend;
- 2) calculation of the forecasting using harmonic weights.

We estimate the additive statistical trends of total public external debt in billion USD for the segment width length 6 years. As a result, segment linear trends of the studied parameters are calculated, evaluation factors are shown in Table 3, where  $t (t = 1, 2, \dots, 16)$  – index of segment trends.

Table 3

**Estimates of the coefficients of linear segment trends**

$t$	Period	$a_t$	$a_0$	$t$	Period	$a_t$	$a_0$
1	1996–2001	0,2714	9,6	9	2004–2009	2,7622	6,22
2	1997–2002	–0,1086	11,147	10	2005–2010	4,7006	3,2122
3	1998–2003	–0,3314	12,093	11	2006–2011	5,6521	4,1779
4	1999–2004	–0,0314	11,127	12	2007–2012	5,1998	10,337
5	2000–2005	0,3629	9,6133	13	2008–2013	3,8321	18,835
6	2001–2006	0,3114	9,9267	14	2009–2014	2,0252	28,535
7	2002–2007	0,7557	9,2167	15	2010–2015	1,3217	33,819
8	2003–2008	1,3771	8,4313	16	2011–2016	1,4127	35,08

Theoretical predictive value of total public external debt, calculated according to the obtained segment trends, and effective smoothing of the indicator are shown in Table 4, where  $y_t (t = 1, 2, \dots, 16)$  – theoretical predictive value,  $y$  – the result of smoothing estimates.

Similar calculations are conducted in UAH equivalent. Prognostic values of the external guaranteed debt in the next five years and the lower and upper limits of these variables with certainty  $P = 0.95$  are calculated similarly in the next five years and given in Table 5.

Since the growth of sovereign debt happens on a background of constant deficit financing of the state budget advisable to investigate the dependence of the total foreign debt of Ukraine on state budget deficit. Figure 5 presents the dynamics of the budget deficit Ukraine for 2007–2015, built according to Table 1.

Table 4

## Theoretical predictive value of total public external debt and effective smoothing

№	$y_1$	$y_2$	$y_3$	$y_4$	$y_5$	$y_6$	$y_7$	$y_8$	$y_9$
1	9,8714								
2	10,1428	11,0384							
3	10,4142	10,9298	11,7616						
4	10,6856	10,8212	11,4302	11,0956					
5	10,9570	10,7126	11,0988	11,0642	9,9762				
6	11,2284	10,6040	10,7674	11,0328	10,3391	10,2381			
7		10,4954	10,4360	11,0014	10,7020	10,5495	9,9724		
8			10,1046	10,9700	11,0649	10,8609	10,7281	9,8084	
9				10,9386	11,4278	11,1723	11,4838	11,1855	8,9822
10					11,7907	11,4837	12,2395	12,5626	11,7444
11						11,7951	12,9952	13,9397	14,5066
12							13,7509	15,3168	17,2688
13								16,6939	20,0310
14									22,7932

Continued Table 4

№	$y_{10}$	$y_{11}$	$y_{11}$	$y_{12}$	$y_{13}$	$y_{14}$	$y_{15}$	$y$
1								9,8714
2								10,5906
3								11,0352
4								11,0082
5								10,7618
6								10,7016
7								10,5261
8								10,5895
9								10,8650
10	7,9128							11,2890
11	12,6134	9,8300						12,6133
12	17,3140	15,4821	15,5368					15,7782
13	22,0146	21,1342	20,7366	22,6671				20,5462
14	26,7152	26,7863	25,9364	26,4992	30,5602			26,5484
15	31,4158	32,4384	31,1362	30,3313	32,5854	35,1407		32,1746
16		38,0905	36,3360	34,1634	34,6106	36,4624	36,4927	36,0259
17			41,5358	37,9955	36,6358	37,7841	37,9054	38,3713
18				41,8276	38,6610	39,1058	39,3181	39,7281
19					40,6862	40,4275	40,7308	40,6148
20						41,7492	42,1435	41,9464
21							43,5562	43,5562

Table 5

**Estimated value of the external guaranteed debt**

Years	External publicly guaranteed debt, billion UAH			External publicly guaranteed debt, billion USD		
	forecasting value	lower boundary	upper boundary	forecasting value	lower boundary	upper boundary
2017	1129,8875	1084,057	1175,718	45,3549	44,4198	46,29
2018	1233,395	1154,4727	1312,3173	47,1536	45,5433	48,7639
2019	1350,9025	1245,278	1456,5472	48,9523	46,7967	51,1079
2020	1461,41	1333,289	1589,531	50,751	48,1368	53,3652
2021	1571,9175	1424,505	1719,33	52,5497	49,5419	55,5575

Figure 5

**The dynamics of the budget deficit, % of GDP**

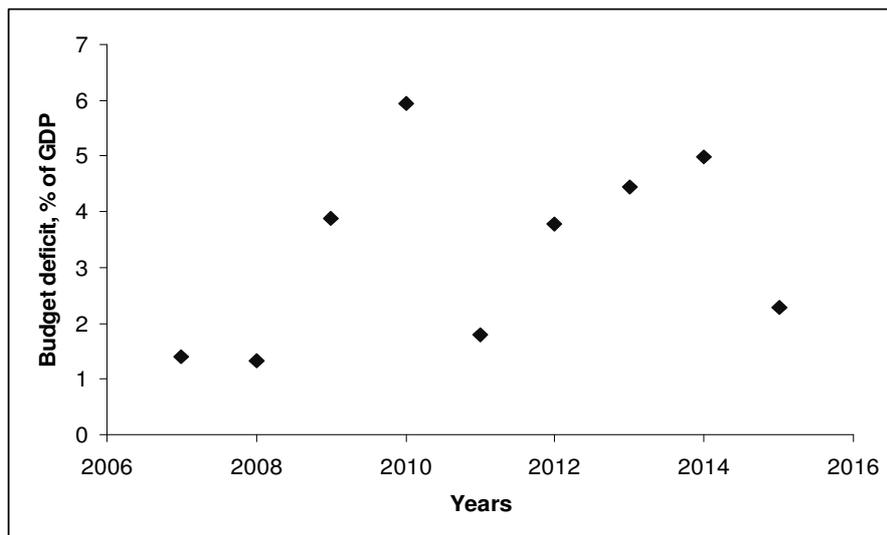


Figure 5 clearly reveal two branch of the growth: I – from 2007 to 2010, II – from 2011 to 2014, describing the pre-crisis and post-crisis periods respectively. In the crisis period the budget deficit increased in 4.5 times from 1.32% to 5.94% of GDP. In 2011 through the actions of the government there was a sharp decline in the budget deficit to 1.79% of GDP, after which the budget deficit annual increased and reached 4.98% in 2014. In 2015 the government reduced the budget deficit to 2.28% of GDP. The direct linear relationship between the value of total external public debt in UAH and budget deficit was founded during the crisis by constructing econometric models with a high degree of reliability  $y = 41,856x + 32,979$  ( $R^2 = 0,9829$ ), where  $y$  – total foreign debt,  $x$  – budget deficit (% GDP). According to this model, increasing the budget deficit by 1% led to an increasing in the total foreign debt to 41.856 billion UAH. The increasing in the budget deficit by 1% led to an increase in debt to 3.8762 USD according to the next model  $y = 3,8762x + 11,61$  ( $R^2 = 0,9717$ ). The inverse dependence indicates that increasing debt by 1 billion USD led to an increase in the budget deficit to 0.2507% of GDP according to the model  $y = 0,2507x - 2,8218$  ( $R^2 = 0,9717$ ), where  $y$  – the budget deficit (% GDP),  $x$  – total external public debt. The tendency of increasing budget deficit on debt in dollar terms retained in the post-crisis period.

Thus, as observed V. Fedosova, without a balanced economic policy will be formed a vicious circle of constant increase in the budget deficit and public debt that will gain momentum until the government to take a set of debt management. This phenomenon is called «debt spiral» (Fedosova, Yuriy, 2010, p. 248).

State Debt displayed on socio-economic indicators of living standards in Ukraine: the minimum and average wage, living wage, minimum and average pensions, costs and savings of the population respectively.

Figure 6 submitted the trend of costs and savings in UAH for the years 1996–2016, which is well described quadratic almost functional dependence

$$y_t = 4,8859t^2 - 15,183t + 11,938 \quad (R^2 = 0,9862).$$

Despite the beginning of the economic crisis in Ukraine in 2008, the trend of costs and savings for 2008–2015

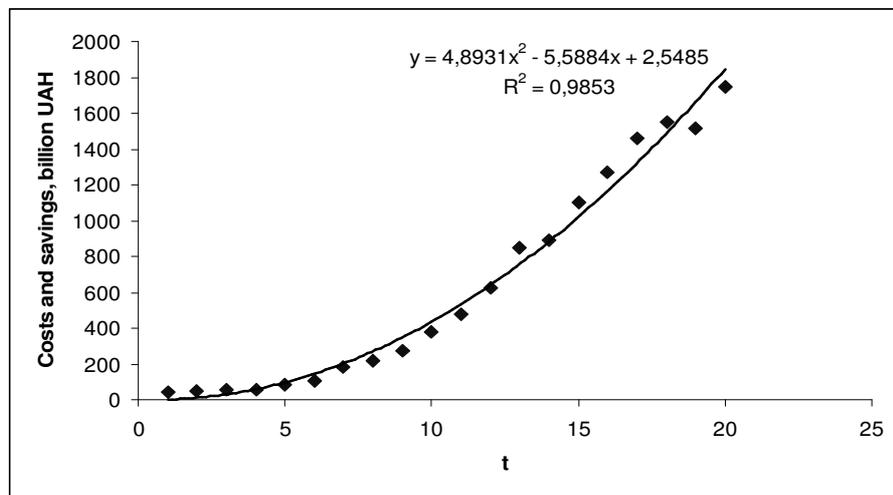
$$y_t = 130,17t + 711,12 \quad (R^2 = 0,9585)$$

shows that the level of the indicator is growing annually by of 130.17 billion UAH in average. Fisher criterion is used to investigate the adequacy of the model. It is calculated  $F_{emp} = 13.86$ . Since  $F_{emp}$  is greater than  $F_{kr} = 5.99$  for reliability level  $p = 0.95$  the model is adequacy. The Durbin-Watson method is used to investigate the residual autocorrelation. It is calculated  $DW_{emp} = 1.7772$ . It is impossible to make definite conclusions about the presence of autocorrelation for reliability

level  $p = 0.95$  and  $n = 8$  ( $d_L = 0,76$ ;  $d_U = 1,33$ ). The autocorrelation is absent to lower reliability. The Glejser-test is used to check of heteroscedasticity in which the linear regression of the absolute values of residues should look as  $|u_t| = 4,7648t + 26,491$ . For numbers degrees of freedom  $k = 6$  and level of reliability  $p = 0.95$  ( $t_{kp}=2,447$ ),  $t_\beta = 0,1615$ . That indicates the insignificance angular coefficient and thus absence of the heteroscedasticity.

Figure 6

**Trend costs and savings in UAH (1996–2015 years)**



Prognostic values of the indicator while maintaining the tendency of the economy in 2016, 2017, 2018, 2019, 2020 and 2021 respectively by the linear model may be 1882.65; 2012.82; 2142.99; 2273.16; 2403.33; 2533.5 billion UAH and respectively by the quadratic model – 1847.78; 2042.69; 2247.37; 2461.82; 2686.05 and 2920.05 billion UAH.

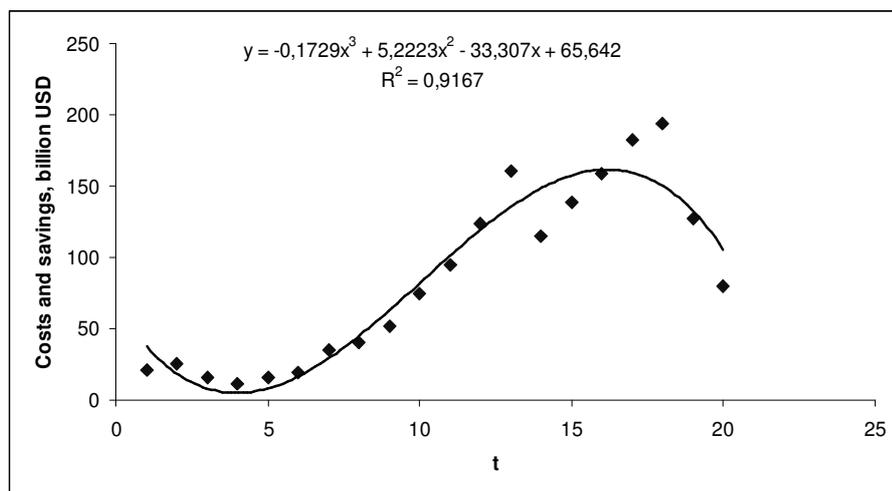
Trend costs and savings in dollars in general very well described by cubic model that reflects the general trend of development

$$y_t = -0,1729t^3 + 5,2223t^2 - 33,3t + 65,642 \quad (R^2 = 0,9167).$$

However, in our view, this trend should be divided into three periods: from 1996 to 2000 a minor fluctuation values of the indicator was experienced; from 2001 to 2008 (the stable development of the economy) the rising of costs and savings by 19.28 billion USD on average each year accordingly linear dependence was happened; in 2009 a significant decrease in this index in dollars compared with 2008 was experienced due to a significant increase of the rate of dollar. However, from 2009 to 2013 (economic crisis, accompanied by a significant increase in the dollar rate) the value of this indicator continued to grow from 114.782 to 193.761 billion USD, average for the year to 20.163 billion USD. From 2014 until now there is a significant decline in spending and savings in dollars from 127.569 to 79.794 billion USD in connection with the new abrupt growth of the dollar. Thus, the costs and savings of the population of Ukraine in local currency is rising and in the dollar falling in recent years. As the world average standard of living is generally measured in dollars, it should be noted poverty of Ukraine's population. With the trend of the dynamics of costs and savings Ukraine (Figure 7) it is evident that if the pace of the decline in living standards, since 2018 the population will not be able to save money, and since 2019 the population lack the funds to maintain its life (survival).

Figure 7

**Trend costs and savings in dollars (1996–2015 years)**



According to (Kucher, 2007, p. 18) there is a correlation (correlation coefficient is 0.79066) for the period 1991–2004 years between the amount of debt and nominal income of the population.

It is important to investigate the effect of debt in UAH on the costs and savings in UAH [3, p. 48]. The tendency of rising costs and savings along with the build-up of debt in UAH is observed during the years 1996–2013. The next econometric model

$$y = 4,637x - 6,5052 \quad (R^2 = 0,8921),$$

where  $y$  – the costs and savings (billion UAH),  $x$  – debt (billion USD), shows that the increase in debt by 1 billion UAH accompanied by rising costs and savings to 4.637 billion UAH. This shows that part of the debt is to maintain social standards of living. The expansion expenditures in debt financing increases to the nominal income: directly (through wages of public sector employees, social transfers, etc.) and indirectly (through spending on other areas that affect on nominal income). This causes an increase in demand along with the inability of the economy to increase production of social product, which is one of the factors of price growth. During the years 2014–2015 there is the tendency to slow down the positive impact of foreign borrowing for consumption and savings because social programs are curtailing in objective reasons.

Dependence of costs and savings in dollars on debt in dollars can be described by quadratic dependence

$$y = -0,3573x^2 + 21,433x - 150,09 \quad (R^2 = 0,763).$$

From Figure 8 shows that from 1996 to 2008 there is the increasing in costs and savings in the USD together with the build-up of debt in dollars. In 2009, due to the sharp rise of the dollar, cost-savings in dollars is declined, followed by an increase of this magnitude, which reaches the maximum in 2013 to 193.767 USD, and since 2014 is its decline due to the new «jump» growth of the dollar. The debt in dollars rose steadily. This indicates a significant outflow of funds borrowed to overcome the negative effects of war in Eastern Ukraine and inefficient using of borrowed foreign funds.

It should be noted that the impact of debt on costs and savings may occur with some delay or time lag. To justify a lag or lags mutual correlation function is used [17 p.216–218], the calculated values of which are given in Table 6. Accordingly Table 6 the mutual correlation function shows the most important up to a year, so the positive results of external borrowing in the current period show up in next year. This dependence can be described by a linear

$$y_t = 4,2848x_{t-1} + 98,465 \quad (R^2 = 0,8702)$$

and quadratic

$$y_t = -0,0086x_{t-1}^2 + 7,8382x_{t-1} - 88,427 \quad (R^2 = 0,9119)$$

models.

Figure 8

Dependence of costs and savings from debt in USD (1996–2015 years)

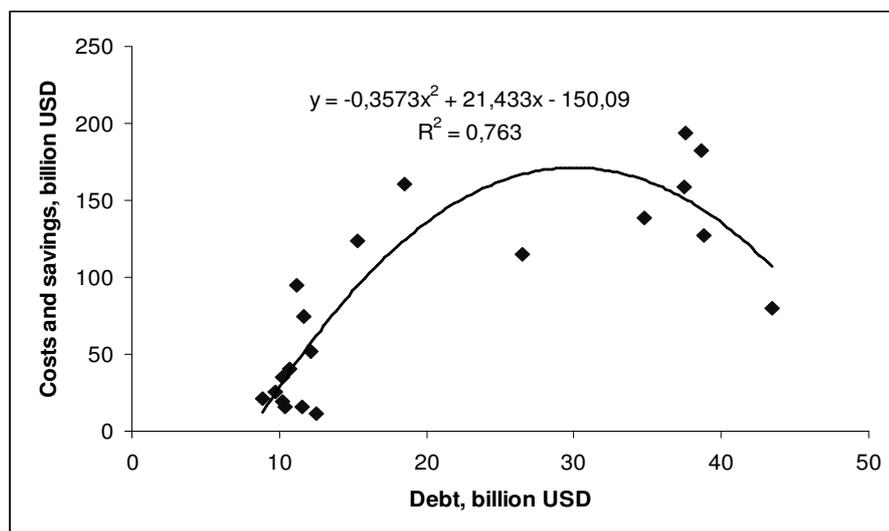


Table 6

Mutual correlation function depending of the costs and savings on public debt in UAH

Lag time	$\tau = 0$	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$
The coefficient of correlation	0,8344	0,9328	0,9129	0,8654	0,7977	0,7307

With linear model implies that the increase in total external public and publicly guaranteed debt by 1 billion UAH accompanied by increasing costs and savings in a year to 4.2848 billion UAH. However the impact of foreign debt on revenue growth and spending in the UAH equivalent can not accurately predict in condition the constant devaluation of the UAH against the dollar and the significant costs of servicing foreign debt.

As the US dollar is one of the world's currencies, will analyze the impact of the debt in dollars on spending and savings in dollars. Similarly in Table 7 the calculated values of mutual correlation function depending of these indicators are presents.

Table 7

**Mutual correlation function depending of the costs and savings  
 on public debt in dollar terms**

Lag time	$\tau=0$	$\tau=1$	$\tau=2$	$\tau=3$	$\tau=4$	$\tau=5$
The coefficient of correlation	0,7594	0,7241	0,6325	0,5064	0,3391	0,1565

Table 7 shows that the maximum value of a mutual correlation function reaches this year. The model of depending cost and savings on state debt in dollar terms is  $y_t = 3,6858x_t + 8,5895$  ( $R^2 = 0,5766$ ). Thus, the increase in debt in this period is by 1 billion USD is accompanied by increasing of the spending and savings in the same period on 3.6858 billion USD. The difference in the values shift in UAH and dollar terms was occurred due to the devaluation of the UAH. Adequacy of all proposed above econometric models were confirmed with the inspection according to known criteria. Because debt is a random variable,

Since debt is a random variable for more detailed analysis, we constructed the econometric model with instrumental variables (Novak, 2004, p.137–140; Nakonechnyi, Tereshenko, Romaniuk, 2000, p. 232–239) depending of the costs and savings on debt in UAH:  $y_t = 45,43005 + 1,067699y_{t-1} + 0,024325x_t$  ( $R^2 = 0,9854$ ), where  $y_t$  – costs and savings (billion UAH) in the  $t$  period,  $y_{t-1}$  – costs and savings in the previous period,  $x_t$  – debt (billion UAH) in the  $t$  period.

The model shows that the costs and savings are incremental in nature, since the increase in spending and savings in year by 1 billion UAH leads to increasing costs and savings to 1.067699 billion UAH next year. The growth of debt in year by 1 billion UAH leads to increasing costs and savings in the year to 0.024325 billion UAH. To analyze the adequacy of the constructed econometric model standard error of estimates of model parameters are calculated:  $Sa_0 = 27,2874$ ;  $Sa_1 = 0,0740$ ;  $Sa_2 = 0,1858$  and empirical values Student  $t$ -test:  $t_{a_0} = 1,6649$ ;  $t_{a_1} = 14,4282$ ;  $t_{a_2} = 0,1309$ . Their comparison with the critical values of the Student's  $t$ -test indicates the importance or high reliability of estimated parameters for a given value of cost and savings shifted to single lag time. It follows that estimated parameters are significant for a given value of cost and savings with the high degree of reliability.

With the model implies that debt is positive, but not enough significant impact on costs and savings. This is due to the political and economic crisis and the increasing in government expenditures Ukraine for defense of the country due to

prolonged military conflict in Eastern Ukraine and increased government spending to service their debt.

## Conclusions

The models of the trend dynamics of the public and publicly guaranteed external debt of Ukraine, the budget deficit, spending and savings of Ukraine in UAH and dollar terms since 1996 to the present are presented.

Based on the analysis of the dynamics of these indicators the following periods are highlighted: 1996-2006 years – a period of sustained economic development (pre-crisis) characterized by slow growth of debt; 2007–2011 years – a period of rapid growth in debt (crisis); 2012–2014 years – a period of slowing growth of debt (post-crisis); since 2015 to the present – a period of new economic crisis.

The predictive values and the lower and upper limits of the total external public debt for the 2016–2021 years in dollar and UAH equivalent are calculated based on the analysis of trends dynamics models and using two methods. Note that the method of harmonic scales, used for the prediction, based on the principle of the aging information is enough reliable. But due to the complexity of the calculations, unfortunately, is almost never used in economic research.

The linear econometric models interdependencies values of total external public debt and budget deficit are calculated, according to an increasing of the budget deficit by 1% of GDP leads to an increasing in total external debt to 41.856 billion UAH and 3.8762 billion USD. The increasing of the debt by 1 billion USD led to an increasing in the budget deficit to 0.2507% of GDP.

The econometric models depending of spending and savings on debt in UAH and dollar terms are constructed. With model follows that growth of total external debt of the state by 1 billion UAH accompanied by rising spending and savings to 4.637 UAH, indicating the positive role of foreign borrowing to maintain social standards of living.

The distributed lag model depending of spending and savings on debt in the UAH equivalent with a delay in one year are constructed and reasonably, according to the increasing of external public debt by 1 billion UAH is accompanied by increasing spending and savings to 4.2848 billion UAH next year.

The distributed lag model depending spending and savings on debt in dollar terms without bias is constructed and reasonably, according to the increasing in external public debt by 1 billion USD enables to increasing public spending and savings this year to 3.6858 billion USD. Both models show good consistency growth factors.

The model with instrumental variables is calculated, whereby the spending and savings are incremental in nature, since the increasing of the spending and savings by 1 billion UAH leads to increasing spending and savings to 1.0677 billion UAH. In turn, the growth of debt in the current year by 1 billion UAH leads to increasing spending and savings in the same year to 0.0243 billion UAH. With this model implies that debt has positive but not significant affect on the spending and savings.

In order to address the existing problems and negative aspects of the existence of public debt should be carried out not only a balanced debt policy and multilateral economic policy that must implemented in directions of reduction or complete elimination of the budget deficit.

### **Prospects for further research**

As recently risks associated with the restructuring of external debt and increasing spending on maintenance are growing, the problem of management of external debt and its servicing is one of the main for Ukraine. The results and the development of the national financial system based on market principles, integration of Ukraine into the world economy, the presence of significant amounts of accumulated public debt and lack effectiveness of management tools of sovereign debt necessitate further research this issue.

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