Statistical analysis and modeling of financial indicators of social economic policy of Ukraine

N.V. Burkina[1], K. Sapun[2], R.V. Seleznova[3], D. Sobon[4]

[1] Donetsk University named after V. Stus, Ukraine, PhD., docent
[2] Varna Free University "Chernorizets Hrabar", Bulgaria, PhD student
[3] Kyiv National University named after T. Shevchenko, Ukraine, PhD., docent
[4] Academy Jakub from Paradis in Gozhov Velkopolsky, Poland

Abstract: The aggravation of social and economic problems in Ukrainian society requires a detailed scientific analysis of the directions and amounts of social expenditures of the State Budget of Ukraine. ARMA models built prove the future increase in incomes of the population of Ukraine, as well as budget revenues of the state. The main driver of this growth we consider wage growth, combined with a decrease in the rate of inflation. Thus, situation in the economy of Ukraine, despite the preservation of significant problems and risks, indicates the gradual formation of a qualitative basis for further stable economic development in new economic realities.

Keywords: ARMA model, Durbin-Watson statistics, OLIMP model, Box- Jenkins model, sustainable development.

1. Introduction. Indicators of living standards in the conditions of European integration

The current stage of development of the Ukrainian economy is difficult and unstable. The change in the vector of foreign trade, the high level of criminalization and shadowing of the economy, the difficult situation in the east of the country, the crisis of the banking and financial sectors, the pandemic have negatively affected the material well-being of most Ukrainians. Under such conditions, the priority of state regulation of the economy is the formation of effective fiscal policy(Собонь Д., 2016 v.4). Revenue policy is an important component of socio-economic policy and one of the important elements of public economic management. The standard of living of the population, its social protection aimed at

increasing life expectancy, the well-being of regions and their sustainable development depend on income (Собонь Д., 2016 v.3).

The aggravation of social and economic problems in Ukrainian society requires a detailed scientific analysis of the directions and amounts of social expenditures of the State Budget of Ukraine. A special place among them, given the hostilities in the east and the global pandemic, are military spending and innovation, which indirectly affect the health of the nation, which is not only a priority of the government, but also an integral part of the economic system.

The budget system is the leading link in public finance. Therefore, more and more attention is paid to issues related to the expenditure part of the state budget of Ukraine.

The purpose of the work is to study the expenditure part of the state budget of Ukraine, in particular the factors that affect it, as well as modeling and forecasting the income of the population.

The most important aspects of income generation and expenditure were studied by foreign and domestic scientists: S. Belozyorov, N. Geronina, O. Sviridonov, L.Okuneva, Yu. Rusanov, and others.

The analysis of the research results testifies to the expediency of further study of the problem of state budget expenditures and household incomes in the system of indicators of living standards in the conditions of European integration (N. Burkina, 2020).

Expenditures of the state budget for 2008-2019 were taken from the site of state statistics of Ukraine and are given in table 1.

Table 1.

Expenditures of the State Budget of Ukraine

Years	Expenditures of the state budget, mln. Uah.
2008	309 216
2009	307 312
2010	377 873
2011	416 854
2012	492 455
2013	505 844
2014	523 126
2015	679 871
2016	835 590
2017	839 244
2018	985 842

2019	1 072 892

Source: Eurostat.

The Foster—Stuart method proved the statistical homogeneity of series number of dynamics in which there is a tendency (Foster F. G., Stuart A., 1954). This makes it possible to model this trend.

2. ARMA models analysis

Among all the trendy models, the best approximation was demonstrated by the most dynamic curves such as parabola of the 2nd and 3rd orders, as well as the exponential function.

Analysis of additive trend models showed that the coefficient of determination is greater in the equation of parabola (0.9828>0.9806), also it has a smaller approximation error, then we will choose it for forecast.

$$y = 4560.2\ x^2 + 12081\ x + 286638$$

The confidence interval of the trend was calculated with 3 SE, and the forecast can be seen in Table 2.

Table 2.

Forecast and confidence intervals of expenditures of the state budget

Forecast year	K*	Se*K*	Forecast values, mln UAH		
			$\hat{y}(t+L)$	Trust interval $\hat{y}\ (p+L)$	
				bottom limit	upper limit
2020	2.13	70731.99	1214364.30	1143632.81	1285096.79
2021	2.20	73202.32	1349571.20	1276368.88	1422773.52
2022	2.28	75925.34	1493893.00	1417972.66	1569823.34

Source: own.

We can assume with probability of 0.95 that while maintaining the trend, in 2022 the budget expenditures of the state will reach 1,493,898 million UAH, while it is possible to change it in the range from 1,417,972 to 1,569,823 million UAH. In the future, under other equal conditions, the growing trend will continue.

Considering the enhanced impact of recent years on the forecast values of budget expenditures of the state, it is possible to build a series of adaptive forecasting models. Among the ARMA models built, linear and parabolic Brown models the best was again parabolic model of Brown with the indicator α= 0.53, which on the one hand emphasizes the

rapid dynamics of the state budget expenditures in the future. According to it, the forecast value of expenditures of the state budget for 2022 will be UAH 1,200,408 million at intervals from UAH 1,076,779.5 to UAH 1,324,035.8 million UAH.

The next step of the study was to check for autocorrelation. The hypothesis H_0 about the absence of autocorrelation was tested according to the statistics of Durbin - Watson according to which the resulting value of the criterion $d_p = 0.018$, which compared to the plate values $d_{L,a}=0.971$ and $d_{U,a}=1.331$ ($d_{L,a} < d_{U,a}$) proves the ignorance of the main hypothesis and emphasizes the existing positive autocorrelation.

To determine the lag of the auto-regression model, the autocorrelation coefficient was applied of the k-th order, followed by its verification according to the Student's t-criterion.

Built autoregression model with lag 3 looks like:

$$\hat{Y} = 24748.52 + 0.646Y_{t-1} + 0.045Y_{t-2} + 0.506Y_{t-3}$$

Relative error of approximation is 6.68%. It can be argued with probability of 0.95 that in 2022 the budget expenditures of the state may amount to 1,930,258.3 million UAH, while possible limits of its changes from 1,786,994.5 to 2,073,522 million UAH.

Meaning the strong enough auto-regression properties of the selected indicator, a series of ARMA models were also built, particularly, Box-Jenkins, OLYMP and Holt's models. The Pivot Table (Table 3)of all ARMA models and their indicators will lead one to choose the highest quality model with the smallest errors, that is the OLYMP model.

Table 3.

ARMA Models and Their Properties

	Paired	Multifactor	Box- Jenkins	OLYMP	Holt's
Relative error of aproximation, %	9.17	6.68	7.6	6.0	8.5
The coefficient of determination	0.96	0.97	0.94	0.94	0.94
2020 year	1459417.53	1309077.17	1148923.50	1217053.12	1217231.75
2021 year	1962850.88	1591808.48	1225450.25	1344483.50	1352627.50
2022 year	2618550.94	1930258.27	1301761.50	1502923.75	149721.63

Source: own.

Thus, the study conducted undoubtedly prove the existing clear trend of expenditures of the State Budget of Ukraine in time toward a significant increase.

The next stage of the study is aimed at clarifying other factors of influence on the expenditures of the state budget, except for time. To do this, a series of indicators were considered, the statistical values of which are given in Table. 4: working in the state sphere, thousand people (X1); expenditures on military affairs, thousand UAH. (X2); innovations, thousand UAH (X3); the profits in banks, mln UAH. (X4).

Table 4.

Factors influencing the expenditures of the state budget

Years	Expenditures of the state budget, mln. UAH (Y)	Working in the state sphere, thousands of people (X1)	Expenditures on military affairs, thousand UAH. (X2)	Innovations, thousand UAH (X3)	The profits in banks, mln UAH (X4)
2008	309 216	58.1	605 000.5	107 205.0	874
2009	307 312	57.4	817 444.6	108 251.0	1635
2010	377 873	57.2	1 240 169.9	108 575.0	2112
2011	416 854	60.9	1 018 277.4	106 584.0	4183
2012	492 455	59.4	1 273 302.2	108 920.0	2391
2013	505 844	58.5	1 440 561.0	108 294.0	3194
2014	523 126	53.8	1 312 634.6	116 041.0	1998
2015	679 871	58.3	1 301 572.8	113 628.0	8222
2016	835 590	56.8	1 536 330.1	113 221.0	912
2017	839 244	57.4	1 749 303.9	113 678.0	1765
2018	985 842	59.2	2 055 655.8	107 801.0	2661
2019	1 072 892	58.1	2 329 464.3	114 528.0	4106

Source: own.

To determine the degree of influence of the selected indicators on the expenditures of the state budget and some, received a correlation matrix, given in Table 5.

Table 5.

Correlation matrix of indicators of influence on expenditures of the state budget

	Y	X1	X2	X3	X4
Y	1.00				

X1	0.01	1.00			
X2	0.94	0.00	1.00		
X3	0.53	-0.67	0.47	1.00	
X4	0.20	0.33	0.18	0.19	1.00

Source: own.

From the matrix we see that the greatest impact on Y expenditures of the state budget have such indicators as: expenditures on military affairs (0.94) and innovations (0.53).

According to the selected indicators, a regression model with high quality indicators was built: R2=0.89, F=34.8, according to the Student's *t*-criterion, the error of each factor does not exceed 3%:

$$y = -108654.35 + 0.4772x_2 + 9.3390x_3$$

To predict according to this model, models of time series of factors were built.

For X2 (expenditures on military affairs), the parabolic model of Brown was optimal. The relative error of approximation of this model is only 4.56%.

To build a forecast for the X3 parameter, the best auto-aggression model of Box-Jenkins with a relative 2.6% approximation error was detected as optimal. According to this model, in 2020, innovation expenditures may amount with a probability of 0.95 to UAH 115,057 thousand, in 2021 UAH 115,704 thousand, in 2022 UAH 116,351 thousand.

According to the multifactorial model (В.В. Зубарев et all, 1994), the forecast values of expenditures of the state budget will be: 2020 UAH 1,170,210.8 with fluctuations from UAH 961,133 thousand to UAH 1,379,289 thousand, in 2021 UAH 1,235,419.165 thousand, with the range of fluctuations from 1026341 thousand UAH to 1444497 thousand UAH.

Obviously, the expenditures of the state budget are closely related to the income of the population. Similarly, the study of incomes of the population of Ukraine was conducted and predicted for future years. The statistical base was obtained from the website of state statistics of Ukraine (Table 6).

Table 6.

Income of the population of Ukraine, mln UAH

Years	Incomes of the population of Ukraine

2007	623 289
2008	845 641
2009	894 286
2010	1 101 175
2011	1 266 753
2012	1 457 864
2013	1 548 733
2014	1 516 768
2015	1 772 016
2016	2 051 331
2017	2 652 082
2018	3 248 730

Source: own.

According to the Durbin-Watson statistics $d_p = 0.028$, $d_{L,a} - 0.971$, $d_{U,a} - 1.331$, and $d < d_{L,a}$, that is, the series has a positive auto-correlation. According to the Student's t-criterion for autocorrelation coefficients, it is found out that the lag of this model is 1. The built-in auto-regression model looks like:

$$\hat{Y} = -100633 + 1.24 Y_{t-1}$$

With a probability of 0.95 it can be argued that in 2021 the incomes of the population may be 5774241.92 million UAH, while possible limits of its change from 5430689.8 to 6117794 mln UAH.

In addition, complex ARMA models of Box-Jenkins (Box, 1994), Olympus and Holt were also built. The consolidated results of the models built and their characteristics are given in Table 7.

Table 7.

ARMA models of income of the population of Ukraine

	Paired	Box-Jenkins	OLYMP	Holt's
F criterion	88.44	121.85	156.998	110.16
Relative error of approximation, %	7.11	8.8	7.6	8.9
The coefficient of determination	0.96	0.94	0.95	0.93
2019 year	3918957.07	3574740.25	3960285.75	3870678.25
2020 year	4748215.98	3817442.25	4858838.50	4579845.00

| 2021 year | 5774241.92 | 4058525.25 | 5998522.50 | 5326441.50 |

Source: own.

The best paired model of auto-regression was chosen, because the relative error of approximation is the smallest and the coefficient of determination is the biggest, compared to other models.

3. Findings

Models built prove the future increase in incomes of the population of Ukraine, as well as budget revenues of the state. We consider the main driver of this growth wage growth, combined with a decrease in the rate of inflation (К.В. Сапун, Р.В. Селезньова, 2018). Indexation of social assistance also had a positive impact on income: pension reform ensured the increase of pensions, while pensions for working pensioners were revised. Thus, situation in the economy of Ukraine, despite the preservation of many of significant problems and risks, indicates the gradual formation of a qualitative basis for further stable economic development in new economic realities.

References

- Burkina N., Taras F., Soboń J., Sapun K., (2020) *Regional differentiation for life quality of the population in Ukraine under innovative growth.* "Financial Internet Quarterly" Volume 16, Issue 2.
- Foster F. G., Stuart A. (1954) *Distribution-free tests in timeseries dated on the breaking of records*, J. Roy. Stat. Soc. Vol. B16, N 1.
- Jenkins B., Reinsel G.M., Gregory C. (1994). *Time Series Analysis: Forecasting and Control* (Third ed.). Prentice-Hall.
- Зубарев В.В., Лысогор В.Н., Селезнева Р.В., (1994) *Моделирование различения стадий многостадийного технологического процесса*, „Вісник Вінницького політехнічного інституту", т.1.
- Сапун К.В., Селезньова Р.В., (2018) Концепція інклюзивного зростання в економіці. (2018) *Вісник студентського наукового товариства ДонНУ імені Василя Стуса; ДонНУ ім. В. Стуса* Volume 1, Issue 10.

- Собонь Д. Налоговая стратегия и цели и функции местной налоговой политики (2016) *Globalization, the State and the Individual.* Journal. Free University of Varna, volume 4.
- Собонь Д. Основания рациональной налоговой стратегии в сфере льгот и налоговых освобождений (2016). *Globalization, the State and the Individual*, v. 3.